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**POLLUTION OF LAKE SUPERIOR AND ITS
TRIBUTARY BASIN, MINNESOTA-WISCONSIN-
MICHIGAN. PROCEEDINGS OF CONFERENCE
HELD AT DULUTH, MINNESOTA ON MAY 13-15, 1969
VOLUME I**

**Federal Water Pollution Control Administration
Washington, D.C.**

15 May 1969

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PROCEEDING

Volume I



May 13-14-15, 1969
Duluth, Minnesota
Executive Session
September 30-October 1, 1969
Duluth, Minnesota

CONFERENCE

Pollution of Lake Superior and
its Tributary Basin, Minnesota-
Wisconsin-Michigan

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Conference in the Matter of Pollution of the Interstate Waters of Lake Superior and its Tributary Basin -- Minnesota, Wisconsin, Michigan, convened at 9:30 a.m., Tuesday, May 13, 1969, at the Hotel Duluth, Duluth, Minnesota.

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P R O C E E D I N G S

May 13, 1969

MR. STEIN: I wonder if we can come to order.

Will the conferees come to the head table.

I have one message here for a Mrs. Robert Erickson. I would like to say that from here on out no messages will be announced. If you have a message, you will have to make other arrangements.

We are also going to try to do the best we can to improve the lighting. We ask your cooperation until we can get everything squared away and cleared up. Because we have such a large meeting, I would ask you to have consideration for your neighbors and allow people behind you to see --- that there be no placards displayed in the auditorium. You recognize --- if you are holding one up, the people behind you are not going to be able to see. I think this would help the situation considerably.

We will open this Conference in the matter of pollution of the interstate waters of Lake Superior and its tributary basin.

I would like to call on Mr. David Dominick, Commissioner, Federal Water Pollution Control Administration.

Commissioner Dominick.

MR. DOMINICK: Thank you, Mr. Stein.

Other conferees will be introduced as we go along here, but in the interest of time I will simply introduce at this time the Honorable Carl L. Klein, Assistant Secretary of the Interior for Water Quality and Research. Mr. Klein will chair the first day of this very important conference.

Mr. Klein.

MR. KLEIN: Thank you, Commissioner Dominick.

Opening Statement - Mr. Klein

OPENING STATEMENT BY

HONORABLE CARL L. KLEIN

MR. KLEIN: The conference is now open.

This conference in the matter of pollution of Lake Superior and its tributary basin in the States of Minnesota, Wisconsin, and Michigan is being held under the provisions of Section 10 of the Federal Water Pollution Control Act, as amended, under Section 10(d)(1). The Secretary of the Interior is authorized to initiate a conference of this type "whenever, on the basis of reports, surveys, or studies, he has reason to believe that any pollution referred to in subsection (a) and endangering the health and welfare of persons in a State other than that in which the discharge or discharges originate is occurring."

Section 10(a) then states: "The pollution of interstate or navigable waters in or adjacent to any State or States (whether the matter causing or contributing to such pollution is discharged directly into such waters or reaches such waters after discharge into a tributary of such waters), which endangers the health or welfare of any persons, shall be subject to abatement as provided in this Act."

That is the jurisdiction of this conference. It was initiated by the Secretary of the Interior. It was not initiated on call of the Governors. As specified in Section 10 of the Act, the Secretary of the Interior has notified the official State water pollution control agencies of this conference. These agencies are the Minnesota Pollution Control Agency, the Wisconsin Department of Natural Resources, and the Michigan Water Resources Commission. One

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Opening Statement - Mr. Klein

is missing, as you notice, and that is Canada. We have no jurisdiction even to invite them to this conference.

Both the State and Federal Governments have responsibilities in dealing with water pollution control problems. The Federal Water Pollution Control Act declares that the States have primary rights and responsibilities for taking action to abate and control pollution. Consistent with this, we are charged by law to encourage the States in these activities.

The purpose of the conference is to bring together the State Water pollution control agencies, representatives of the U. S. Department of the Interior, and other interested parties to review the existing situation, and the progress which has been made, to lay a basis for future action by all parties concerned, and to give the States, localities, and industries an opportunity to take any indicated remedial action under State and local law.

The Minnesota Pollution Control Agency will be represented by Mr. John Badalich. The Wisconsin Department of Natural Resources has designated as its conferee Mr. Thomas Frangos. And the Michigan Water Resources Commission will be represented by Mr. Ralph Purdy. The Federal conferee is Mr. Murray Stein. My name, of course, is Carl L. Klein. Mr. David Dominick is the Commissioner of the Federal Water Pollution Control Administration.

In my absence during the remainder of the week when I will be testifying in Springfield, Illinois, on various pollution bills, Mr. David Dominick will be the Chairman with Mr. Murray Stein assisting him.

The parties to this conference are the official State Water Pollution control agencies and the U. S. Department of the

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Interior. Section 10(d)(3) of the Act provides that the agencies called to attend such conference may bring such persons as they desire to the conference. In addition, it shall be the responsibility of the Chairman of the conference to give every person contributing to the alleged pollution or affected by it an opportunity to make a full statement of his views to the conference.

Now a word about the procedures governing the conduct of the conference. The conferees will be called upon to make statements. The conferees, in addition, may call upon participants whom they have invited to the conference to make statements. In addition, we shall call on other interested individuals who wish to present statements. At the conclusion of each statement, the conferees will be given an opportunity to comment or ask questions, and I may ask a question or two. This procedure has proven effective in the past in reaching equitable solutions.

The procedure ordinarily is that the host Governor and other Governors have the first right of making statements and other Federal and State dignitaries as well. Then the Federal Government presents its case, and then turns the microphone and the chair over to the local State agencies. In this case, the State of Minnesota will present all of its witnesses after the Federal Government, this being their home State; thereafter the State of Wisconsin; and finally the State of Michigan. At the end of all the statements we shall have a discussion among the conferees and try to arrive at a basis of agreement on the facts of the situation. Then we shall attempt to summarize the conference orally, giving the conferees, of course, the right to amend or modify the summary.

Opening Statement - Mr. Klein

Section 10 (d) (4) of the Act specifies that,

"Following the conference, the Secretary shall prepare and forward to all the water pollution control agencies attending the conference a summary of conference discussions including (a) occurrence of pollution of interstate or navigable waters subject to abatement under this Act; (b) adequacy of measures taken towards the abatement of the pollution; and (c) nature of delays, if any, being encountered in abating the pollution."

The Secretary is also required to make recommendations for remedial action if such recommendations are indicated, and I will say to you we will take up all of Lake Superior in this matter and not just part of it.

A record and verbatim transcript of the conference is being made by Thomas Couriour of Kansas City, Missouri. We shall make copies of the summary and transcript available to the official State water pollution control agencies.

I would suggest that all speakers and participants other than the conferees making statements come to the lecturn and identify themselves for purposes of the record.

Our first statement this morning is by the Host Governor, the Honorable Harold Levander, Governor of the State of Minnesota.

Governor Levander.

(Applause and standing ovation.)

Honorable Harold Levander

STATEMENT OF THE HONORABLE HAROLD LEVANDER,
GOVERNOR, STATE OF MINNESOTA,
ST. PAUL, MINNESOTA

GOVERNOR LEVANDER: Thank you, Mr. Klein.

And to one and all, and especially to our out-of-State guests, a hearty welcome to Minnesota. We are indeed grateful that each of you have been willing to come, to give your time, and to share your expertise.

Few problems generate greater concern or threaten more massive consequences than the prospect of harmful pollution. The haunting specter of pollution is even more monstrous to Minnesotans than it is to many others because we have become accustomed to, and are very proud of, our undefiled natural resources.

It is out of this spirit of concern that I have welcomed this fact-finding conference on the status of Lake Superior. Lake Superior is more than a nice asset. It is absolutely indispensable, and Minnesota shall not tolerate pollution of this lake from any source. We shall take any action necessary to preserve the high quality of this lake.

In fact, we have already begun. As the Federal Water Pollution Control Administration reports:

"The States assigned their highest use categories to Lake Superior (i.e., public water supply, whole body contact recreation, and cold water fishery). The water quality criteria adopted to protect these designated uses were established using the best available knowledge at that time. Hence, the water quality standards for Lake Superior are the most restrictive adopted by the States

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of Michigan, Minnesota, and Wisconsin, and are among the most stringent standards nationally."

We must keep a vigilant watch over the water quality of one of the largest, purest, youngest, and most delicate lakes in the world. And, therefore, I have looked forward to this conference so that we can update our information on Lake Superior. I note Secretary Udall's language in calling this conference when he wrote, "I would like to stress to you that I consider this conference to be fact finding..." And he closed by saying, "I look forward to our joint efforts and determination of what the facts concerning pollution in Lake Superior really are."

For we must have the facts, and, moreover, we must have a constant analysis of the facts so that we pursue the most proper and vigorous course in fighting pollution. It is for that reason that I instructed the Minnesota Pollution Control Agency several months ago to provide regular spot checks on the quality of the water in Lake Superior.

Yet there is one undisputed fact that Minnesotans fully appreciate. That is, we place great demands on Lake Superior and, therefore, we, in large part, hold its future in our hands. Because this administration recognizes its obligation to generations to come, we have moved and will move swiftly to abate pollution.

Six months ago, all municipalities and industries on the lake were given orders of compliance. Each municipality and every industry is now required not only to provide secondary treatment of their wastes, but we have also gone a step farther to require tertiary treatment or removal of nutrients from the wastes. Each case involved has a specific deadline, but by late 1971 everyone must meet these

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standards.

In addition, to my knowledge, Minnesota is the first State in the Union which now has effluent standards and a minimum of secondary treatment requirements on all discharges, both in intrastate and interstate waters.

Furthermore, I believe Minnesota is the first State in the Nation which has been able to voluntarily work out a legal stipulation by the State, the city, and the company so that the paper mills and all wood product industries using the St. Louis River (the principal river of the Superior Basin) in the area of Cloquet will have secondary treatment of their effluent by 1973.

However, we have not come to recite the past but to assess the present and to protect the future --- a future free from pollution. If we are to be successful, we will need the unceasing cooperation among States and the Province of Canada. Although Minnesota is a prominent user of the lake, with 189 miles of its shoreline, Wisconsin holds 325 miles, Michigan 913, and Ontario 1,549. These governmental units have a vital interest in the lake. It is my opinion, if we are really sincere about the future of Lake Superior, we ought to include in any further discussions or future discussions, Canada. To neglect them is to neglect over one-half the drainage basin of the lake and over one-half of its shoreline.

With this kind of comprehensive, forceful effort I think we can preserve the exceptional qualities of Lake Superior waters.

In conclusion, Mr. Klein, I have one request to make. You met with us in Chicago some few weeks ago with respect to the DDT pollution problem, and we then requested some additional assistance

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in a monetary way from the Federal Government. You have advised us now that there is \$200,000 available on a two-to-one matching basis. I would like this allowance (which would be \$40,000 to Minnesota) to be divided on the basis of \$10,000 from the Federal Government (which we would match with \$5,000) for the DDT investigation; and that \$30,000 of that money (to be matched by \$15,000 from the State) would be used for monitoring any other possible pollution in Lake Superior.

We have in Minnesota now, through our Water Pollution Control Agency, a continuing surveillance program, but this additional financial assistance will enable us to do a even more intensive and comprehensive monitoring program for the lake.

Thank you very much.

(Applause.)

MR. KLEIN: Thank you, Governor Levander.

You know, I am very pleased about this cursory treatment of the removal of nutrient pollutants, and I am very pleased about the dates of 1971 and 1973 that you have already set up. We --- the Commissioner, Mr. Murray Stein, and myself --- have just finished the conference on the Potomac River in Washington, and we are having difficulty in getting a date set of 1973 or even 1975 to get the Nation's rivers cleaned up because of the amount of money involved. I am glad to see that you are a step ahead of us on this.

Our host Congressman for District 8 is the Honorable John Blatnik, and, as is the custom, being the Host Congressman, I have asked him to address you next.

Congressman Blatnik. (Applause.)

Honorable John A. Blatnik

STATEMENT OF THE HONORABLE JOHN A. BLATNIK,

U. S. HOUSE OF REPRESENTATIVES

WASHINGTON, D. C.

MR. BLATNIK: Thank you very much Secretary Klein.

Governor Levander, distinguished members, distinguished conferees, and the associates of our neighbor States of Wisconsin and Michigan:

Welcome and good morning, friends.

I am really pleased to be permitted to be part of those to initiate this official proceeding --- a conference which I shall define here in law as the first stage and the first step in an enforcement action to cause to cease and desist any pollution that may be found to occur in Lake Superior.

Although the Governor made a splendid statement --- Governor, I am pleased to commend you --- on the advanced progress and foresight which the State of Minnesota is showing in the field of pollution control (both in intrastate and interstate waters) may I briefly beg your indulgence and tolerance to recite a little of the past not just to recite the past history but hopefully to give you a clear understanding of where we have been, where we are today, and what further needs to be done. The prime issue, of course, is Lake Superior and all sources of pollution that threaten our great heritage.

I first became acquainted with Lake Superior more than 34 years ago when I was working in the odd CCC camps near Isabella and Finland on Highway 1 between Ely and Lake Superior. I don't ever think I'll forget the first time I saw the big lake. It was a

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bright, sunny day, much like this morning, and when I came over the hill near Illgen City there in front of me was that huge, magnificent, glittering freshwater lake. That was quite a thrill back in the old days when travel was so difficult, and I've had a warm spot for Lake Superior ever since.

That first exciting experience with the lake had a great impact on me, such an impact that in later years I made it part of my life's work. There I was, standing in front of one of the largest bodies of fresh water in the world. To me it looked like an ocean.

The lake's unsurpassed beauty, purity, and clarity were then, and still are, resources to be preserved and protected. The unique quality of its water transcended anything I had ever seen before, and I could feel the richness of the lake's heritage all around me. But I never really appreciated this great pristine resource, this lovely northern lake and forest country until I went to Washington in January 1947, after the War when I first came to Congress.

I was named to the Public Works Committee, which deals directly with many aspects of water use -- navigation, flood control, hydroelectric power, harbors, channels and pollution. I was also named to the Subcommittee on Rivers and Harbors which was working on the problems of the St. Lawrence Seaway.

While reviewing all of the Great Lakes ports, channels and harbors and studying the St. Lawrence Seaway problems, I saw firsthand and was appalled at the unbelievable pollution of the harbors of Chicago, Gary, Detroit, Cleveland, and Buffalo, and the major rivers such as the Ohio, Mississippi, St. Claire, River Rouge,

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as well as practically all of the major seacoast ports -- Boston, New York, Philadelphia, Baltimore, New Orleans, San Diego, San Francisco, etc.

It was then that I began my fight to clean up the Lower Great Lakes, the Mississippi River, and the great pollution problems throughout the Nation.

It was a lonely fight back in those days. Pollution was not the popular issue that it is today. Back then the clean water advocates in Congress could have caucused in a telephone booth. The clean water fighters were few and far between.

But we didn't get discouraged, because it was clearly evident that water pollution was a national problem that was bad and getting worse and that it could only be solved through cooperation by the Federal Government, the State Governments, local governments and industry, and with the understanding and broad-based support of a vast majority of the Nation's citizens.

We needed and got the complete support of the conservation organizations, such as National Wildlife Federation, now under the leadership of Tom Kimball, the Executive Director, who is here with us today; Bill Magie and the Friends of the Wilderness, the Izaak Walton League, the United Northern Sportsmen, and many other dedicated groups.

Especially helpful in the early days and right up to the present was the League of Women Voters. Without this kind of determined grass-roots support we couldn't have done the job.

The big breakthrough came when I was made Chairman of the Subcommittee on Rivers and Harbors and in 1956 was able to author the Federal Water Pollution Act. I conducted the hearings on the bill in

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the Public Works Committee and managed it on the House Floor.

This was the first permanent national law for the prevention, control, and abatement of water pollution. And it was imperative that it be enacted into law. After passing the House by a vote of 338 - 31, and following Senate action on the bill, I filed the report of the Conference Committee and President Eisenhower signed the bill into law on July 9, 1956.

The Federal Water Pollution Control Act laid the groundwork for the start of a joint effort by the Federal Government in full partnership with the States and localities in the clean water fight. The accomplishments of the law were many:

1. It recognized and preserved the primary responsibility and rights of the States in preventing and controlling water pollution.
2. It authorized continued Federal-State cooperation in the development of comprehensive river basin programs for water pollution control.
3. It authorized increased technical assistance to the States and stepped up research.
4. It authorized the collection and dissemination of basic data on water quality relating to the prevention and control of pollution.
5. It encouraged the continued formation of interstate compacts and uniform State laws.
6. It authorized for 5 years grants to States and Interstate agencies for their water pollution control programs.
7. It authorized Federal grants for the construction of municipal waste treatment works.

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8. And, ladies and gentlemen, it set up procedures for enforcement action against interstate pollution -- Yes, the enforcement conference you are sitting at today would not have been possible without the passage of my bill in 1956.

My original bill asked for \$100 million in construction grants. The 1956 Act, as finally passed, authorized annual appropriations of \$50 million for Federal waste treatment construction grants of 30 percent or \$250,000, whichever is less. This was a very modest start indeed -- but it was the best we could get through at that time and it was a start in the right direction.

In 1960 during the 86th Congress, to try to make further improvements and to spur more local effort in the Federal program, I introduced a bill to increase the annual grant authorization. This bill also provided for an increase in the dollar ceiling for a single project and encouraged efficiency and economy by permitting two or more communities to join in a project.

Though we got the bill through the Committee, the House and Senate and the Conference Committee, President Eisenhower vetoed it on the grounds that this was a local problem. By a vote of 249 to 157 the House fell short of the necessary two-thirds vote needed to override the veto.

In 1961 I again introduced legislation to strengthen the Federal Water Pollution Control Act. I also presided at those Committee Hearings and managed the bill on the House Floor, with passage coming on a vote of 307 to 110.

The bill, signed into law by President Kennedy on July 21, 1961, increased the appropriations authorization for construction

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grants to \$100 million a year, finally reaching the \$100 million level we sought in 1956. It also increased the dollar ceiling for a single project to \$600,000, and authorized multimunicipal projects with a dollar ceiling of \$2.4 million. As you can see, the effect of this bill was to increase the incentive to local antipollution efforts.

But I accomplished one other important job in this new law -- direction of a continuing study of the quality of the waters of the Great Lakes to protect them from pollution caused by population growth, industrial growth, and increased shipping.

At this time we knew very little about water quality, and it became very evident that an enormous amount of scientific and technological research was needed to answer the many complex questions.

During the 89th Congress I moved again to strengthen the water pollution legislation and introduced the Water Quality Act of 1965 with Senator Ed Muskie as the lead-off witness. By 1965 we "clean water" fighters were getting good support. The bill passed the House by a unanimous vote and got overwhelming approval in the Senate, as well. It was made law by President Johnson on October 2, 1965.

This landmark legislation created the Federal Water Pollution Administration, and it also provided for the establishment of water quality standards for interstate waters and stated for the first time that the purpose of the Federal Water Pollution Control Act is to enhance the quality and value of our water resources and to establish a national policy for the prevention, control, and abatement of water pollution.

Under this new law we also increased the annual appropriations authorization for construction grants from \$100 million to

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\$150 million, doubled the dollar ceilings, afforded more realistic assistance to populous areas, and gave new incentives to State participation in waste treatment plant financing.

In 1966 we took another big step toward increasing the quality of this Nation's water during the 89th Congress with the passage of the Clean Water Restoration Act, of which I was the author.

The most significant provision of the 1966 Act was the vast increase in the authorized level of Federal support for municipal waste treatment plant construction, the grant program begun in 1956 under my original legislation.

The 1966 Act also removed the dollar ceilings on projects, provided new incentives for State participation in financing and for the application of water quality standards to receiving waters.

Among its other provisions the law authorized 50 percent Federal grants to planning agencies for the development of comprehensive basin plans for water quality control; doubled the level of Federal support for the strengthening of State and interstate water pollution control programs; provided for research and demonstration grants in the areas of advanced waste treatment and wastewater renovation and the control of industrial pollution, plus many other new provisions.

In addition, the 1966 law transferred to the Secretary of Interior responsibility for administration of the Oil Pollution Act of 1924, and expanded its application to include the Great Lakes and other nontidal navigable waters.

The successive amendments to the Federal Water Pollution Control Act and related law reflect the response of Congress

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to the magnitude of the total water pollution problem, its complexity, the emergence and recognition of new problem areas, and the mounting public demand for clean waters.

Congress has not only been responsive with legislation on the enforcement and construction aspects of the program, it has also authorized millions of dollars in research, development, and demonstration projects.

In 1956 the appropriation for these projects was \$443,219. This has grown to \$43,668,846 in 1969. Waste treatment construction grants grew from \$50 million in 1957 to \$214 million in 1969.

This winter I personally conducted an investigation and hearings in Santa Barbara following the disastrous oil spills off the coast off that city. This catastrophe underscored the need for more effective control of pollution of waters and shorelines by oil.

We returned to Washington, conducted hearings on the Water Quality Improvement Act of 1969, and passed it through the House of Representatives on April 16 by a vote of 392-1. I expect early action by the Senate.

This bill would provide for the control of pollution by oil and other matter from vessels, offshore facilities and onshore facilities; from acid and other mine drainage; and from activities operating under Federal licenses and permits as well as from Federal installations. It also authorized more intensive work on the Clean Lakes Program.

The Federal Water Pollution Control Act, enacted in 1956, strengthened in 1961, 1965, and 1966, and the expected enactment of the Water Quality Improvement Act of 1969, all came under my Chairmanship

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of the Rivers and Harbors Subcommittee.

This was work, hard work. It took years of study, hundreds of hours of Committee hearings, and volume after volume of testimony. But it is all worth it if we can help the Lower Lakes and keep Lake Superior the clean beauty that she is.

Back in 1962, I realized that the best way to preserve Lake Superior was through preventive measures. But nobody knew enough about pollution to establish a comprehensive preventive program. The problems of water pollution are so complex, so varied, and so numerous that existing knowledge and techniques are not adequate to deal with all of them. This is where the idea of the National Water Quality Laboratory came in. We simply needed more scientific information about pollution.

I obtained Federal authorization for the laboratory, and the city of Duluth donated the building site in March 1962. The lab was dedicated on August 11, 1967.

What does this all mean? It means that on the shore of Lake Superior standing like a watchful, protective beacon, is a \$2.2 million structure which houses \$1 million worth of the most sophisticated, advanced scientific and technical equipment that American science can produce in this field.

Now we have the most scientifically advanced freshwater laboratory in the world to study and research the environment of Lake Superior waters and determine in a scientific manner the best preventive methods to avoid pollution of Lake Superior.

We also have, as I outlined earlier, a good legislative base from which to embark on an orderly, responsible program of water

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pollution control and effective enforcement where necessary.

Since early this year there has been considerable intensive, often emotionally supercharged discussion about pollution of Lake Superior and about this enforcement conference. Many well-meaning but ill-informed statements have been made proposing action that should be taken by the Federal Government or the State of Minnesota, some even calling for Legislation to stop pollution of Lake Superior.

This kind of talk has confused the people and created a misunderstanding about the Water Pollution Control program and has even led to rumors that attempts are being made to white-wash this enforcement procedure.

As author of the first permanent, comprehensive law to control water pollution and manager in the House of all its major amendments, I feel it is most important to set the record straight on the whole enforcement procedure.

First, let me point out that no NEW legislation is needed now to cope with Lake Superior problems. THAT AUTHORITY HAS BEEN on the Federal statute books for 13 years. All we need to do is implement and enforce the law, and that is precisely what we are here to get under way today. This conference, with official status in the eyes of the law, sets in motion the Federal, and I hope State, legal machinery to abate, prevent, and stop pollution in Lake Superior.

Few people realize that this enforcement conference was called and that our meeting today is being held under the authority of the basic 1956 Blatnik Water Pollution Control Act, and that whatever cleanup action this conference determines should be taken will be taken under the authority of that law. The objective is to

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reduce pollution to tolerable, permissible, harmless limits, and if that can't be done, then to stop it entirely.

Second, I want to emphasize that the enforcement procedure has proven to be both workable and effective in cleaning up polluted waters throughout the United States. Let me underscore this point with a few facts:

This enforcement conference is the 46th in the past 13 years;

Preceding Conferences have issued cleanup orders to;

42 States and the District of Columbia;

1,300 municipalities;

1,800 industries;

89 Federal installations;

73 State or private institutions;

11,168 miles of riverway.

America's most populous States have figured in previous enforcement actions, as have our largest metropolitan areas, such as New York City, Chicago, Detroit, Cleveland, St. Louis, Minnesota's own Minneapolis-St. Paul, and the giants of industry: United States Steel, General Motors, Chrysler, Ford Motor Company, Standard Oil Corporation, Youngstown Sheet and Tube, Republic Steel, International Paper Company, Weyerhaeuser, Crown Zellerbach, Scott Paper Company, and a long list of others.

Corrective action called for by those conferences is under way and in many cases already completed at a total cost of some \$10 billion invested in municipal and industrial treatment plants.

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To give you some recent examples of the magnitude of the cleanup effort resulting from an enforcement proceeding, the Lake Erie conference involved five States, 115 municipalities, 101 industries, and 11 federal installations. A complete cleanup schedule was agreed upon by all the participants at a total estimated cost of \$5 billion.

The Lake Michigan conference held just last year affected 4 States, 124 municipalities, 53 industries, 20 federal installations, and is expected to cost some \$4 billion.

Of all the Great Lakes, the waters of Lake Erie are in the most advanced state of pollution -- perhaps irreversibly so -- and many call it a dying lake. Lake Michigan, though sick, is not anywhere near the degree of aging and decay of Lake Erie and the enforcement action taken there still has a chance of reversing the pollution.

Lake Superior is unique among the Great Lakes -- the least polluted: the largest body of fresh water; the most to be gained from early action. The action on Lake Erie could be termed "STOP GAP" at best: in Lake Michigan, remedial and restorative: in Lake Superior, preventive and preservative. We must, by acting now, prevent pollution from destroying this priceless resource.

And we will do it under the three-step enforcement procedure I wrote into the 1956 law: (1) Conference, (2) Public Hearing, (3) Court Action.

Today we are participating in the first, or conference stage of the enforcement procedure. The role of the conference, which, by the way, is conducted on an informal basis and is not an adversary proceeding, is to establish the facts, such as: the nature

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and extent of pollution, whether measures now being taken to abate pollution are adequate, and the kinds of problems expected to be encountered in preventing pollution. With all the facts before them, the conferees will try to reach agreement on a remedial program of pollution abatement.

If this doesn't work, then we go on to Stage 2, the Public Hearing, which is a formal proceeding directed at individual, alleged polluters. A formal hearing is held before a five-member board appointed by the Secretary of the Interior and sworn testimony is taken. The Board's findings and recommendations are sent to the polluters -- whether State or Federal Government, municipal or private -- and to the State with a timetable for compliance.

Stage 3, Federal Court Action, is the last resort in the enforcement procedure. The court has jurisdiction to enter whatever judgment or order may be necessary to safeguard the public interest.

However, so successful is the conference stage of the enforcement procedure that in the 13 years of the Federal Water Pollution Control Program a public hearing has been required in only four cases, and court action only once.

The purpose of this Duluth Enforcement Conference is to study the pollution problems of the entire Lake Superior Basin. However, because of the close coverage by the news media and a concerned public, the focal point of the conference is the discharge of tailings from Reserve Mining Company's E. W. Davis Works at Silver Bay.

The report indicates that Reserves tailings discharge do have an adverse effect on the quality of the Minnesota waters of

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Lake Superior. If this is determined to be a fact during the conference or at a later date, then the Governor, the Minnesota Pollution Control Agency -- with the help of the Federal Government, and the mining company -- should and must take corrective measures.

Although the Government report indicates that at the present time there is not enough scientific evidence on which to base a finding of interstate pollution, it does recommend that the Federal Water Pollution Control Agency and the State keep the discharge of tailings under continuing surveillance and report back to the conferees at 6-month intervals.

I wholeheartedly support this action.

I will go further and say that, with the help of the National Water Quality Laboratory, if there is pollution anywhere in the lake, we are going to find it. And when we find it, we are going to stop it under the enforcement section already in the law. If there is interstate pollution, then the Federal Government can move in at once to take action. If there is intrastate pollution, there still is no excuse for delay, as the Governors of the three States can act under State law. If they have problems or need help, they need only ask the Federal Government for help and I assure you help will come.

All of us -- the Federal Government, State Government, local government, and industry -- have a tremendous responsibility in keeping Lake Superior as clean as possible. We must protect the high quality of her water, and as long as I have anything to do with it -- it will be protected.

Honorable John A. Blatnik

I want our sons and daughters, their sons and daughters, and generation after generation after generation to experience the exhilaration I did when I got my first look at that beauty out there. This can be accomplished, and this enforcement conference here today is a big step toward determining the best method of preserving Lake Superior as the beauty that she is.

I ask you not only for your interest but active participation, and I look forward to continuing this joint effort to find a satisfactory solution for all concerned.

I thank you, and very sincere best wishes.

(Applause.)

MR. KLEIN: Thank you, Congressman Blatnik.

Your remarks towards the scientific research just brings home a point. My Division in the Department of the Interior does about 70 percent of all water resources research in the Federal Government, and you know we are just beginning to find out what water actually is and what it does under a number of different conditions and what it carries with it in a great many different localities.

You spoke of boats and home owners. I want to bring something home to you because we have run into a problem. It isn't just the other fellow who is doing the polluting, it is you and I also. We expect boat owners who are asking for clean lakes to help in this problem. And we expect home owners who have to pay for the sewage treatment plants by sewage use charges or extra taxes to help with that problem also. It isn't just the other fellow's problem; it is our problem, too, and we all have to work together if we can find an answer to it.

Honorable Warren P. Knowles

We have here today speaking for Governor Knowles of Wisconsin Mr. Les Voigt.

Mr. Voigt. (Applause.)

STATEMENT OF THE HONORABLE WARREN P. KNOWLES
GOVERNOR, STATE OF WISCONSIN,
MADISON, WISCONSIN,
(READ BY L. P. VOIGT, SECRETARY,
DEPARTMENT OF NATURAL RESOURCES.)

MR. VOIGT: Thank you, Secretary Klein.

Governor Levander, Congressman Blatnik, Commissioner Dominick, other distinguished guests, conferees, ladies and gentlemen:

Governor Warren Knowles sends his personal regrets and notes his disappointment that he is unable to be here himself to address this conference. As you know, he is deeply interested in the problems of pollution abatement and has been the motivating force in our State for notable legislation in this field. However, because of the press of legislative business he is not able to be here today and he asked me to read this statement, which he has prepared.

Wisconsin shares with her neighboring States a concern for protecting and maintaining the high quality of the waters of Lake Superior. Recent investigations and reports have indicated that perhaps subtle and irreversible damage may be occurring in these waters. Because of our concern, I have pledged the full cooperation of Wisconsin in the current enforcement conference proceedings called by

Honorable Warren P. Knowles

the Secretary of the Department of the Interior.

Wisconsin's interest in the protection of this magnificent lake is one of long standing. Our State, through the efforts of the Department of Natural Resources, has been actively developing an effective pollution abatement program in the Wisconsin portion of the Lake Superior drainage basin.

Water quality standards have been established under the provisions of Wisconsin Water Resources Act. On the basis of a recent pollution survey of the entire drainage basin orders have been issued against all municipalities and industries whose treatment processes do not measure up to the new -- and high -- standards.

During the past summer, the Division of Environmental Protection conducted a special water quality investigation of Wisconsin waters of Lake Superior, with emphasis on the Apostle Islands area. All of this activity demonstrates I believe a genuine and effective State effort aimed at protecting this vital natural resource.

In other ways, too, Wisconsin has sought not only to preserve the quality of Lake Superior but to improve the quality of life for those in the lake region who have been caught in a vicious squeeze of economic recession while the balance of the Nation prospered.

With other State and Federal agencies we contributed minds, money, and manpower to the battle against the sea lamprey which virtually wiped out a once-flourishing lake trout fishery.

Through decades of patient reforestation and fire control effort we have restored a charred "cut-over" region to a stable and productive forest.

Honorable Warren P. Knowles

Through timely investment we have preserved scenic vistas and have converted them to parks and campgrounds which attract thousands of visitors.

Through the studies and planning of the Red Clay Inter-Agency Committee we have begun a coordinated effort to stabilize the highly erosive red clay soils of northwestern Wisconsin, seeking to stem the sedimentation which at times turns the bays of Lake Superior into a red sea.

And through active support and participation in the Upper Great Lakes Regional Commission, we have sought to stimulate the fluttering economic pulse of this vast three-State region.

This Commission, established on April 11, 1967, has directly encouraged pollution control efforts through its grant-in-aid programs. Beyond this, it has given recognition to the tremendous potential for tourism in the north and has mapped out strategies to develop this potential.

Implicit in the action plans of the Commission is the need to preserve the natural glories of this area, including the unmatched quality of Lake Superior. While the Commission's goals include development of new industrial sinews, at the heart of its programs is the determination that these industries must not exploit or detract from the natural resources which are this northern area's greatest asset.

I have ridden the waves of Lake Superior and fished for its firm-fleshed trout. I have tramped its shores and explored its islands, marveling at its rugged grandeur. I have known its vastness and its violence. It has refreshed my spirit and renewed my perspectives.

Honorable Warren P. Knowles

Because I do feel a strong personal kinship to this great body of water and its surrounding lands, I have been insistent that Wisconsin laws and administrative programs be designed and implemented toward protection of our basic resources.

It has been extremely encouraging to me that of the 30 pollution abatement orders issued by our State last year in the Lake Superior drainage basin, eight of those cited have substantially corrected their problems. Less encouraging -- but still helpful to the cause of clean waters -- is the fact that an additional four pollution sources have ceased to exist.

The majority of the remaining pollution sources in Wisconsin are municipalities which have not yet completed engineering plans for new sewage treatment plants.

Overwhelming voter endorsement of a pollution abatement bonding issue in the spring balloting gives promise that Wisconsin can help its communities meet their sewage treatment obligations.

This bonding authority -- up to \$144 million in the next ten years -- will permit our State to assure communities of at least 55 percent of the funds necessary to construct approved sewage treatment plants and intercepting sewers. This will be accomplished through a combination of State grants and State advances of anticipated Federal funds. Through this device we hope to stimulate the construction of nearly \$300 million worth of pollution control projects in the next several years.

Other than tax incentives provided in Wisconsin air and water pollution control laws, we do not give direct aid to industries. We expect that they will fully comply with State orders, however, and

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have been gratified with their cooperation and response.

This brings me to the issue which, from my appraisal of your conference reports, is the crux of this conference: What steps are necessary to insure that the waters of Lake Superior are not used as a dumping grounds for the by-products of industrial processes?

This conference must also evaluate reports in the news media alleging that a Member of Congress has attempted to interfere with a Federal report identifying a major source of industrial pollution in Lake Superior.

Certainly, we cannot tolerate the pollution of Lake Superior, and we must take whatever steps are necessary to prevent its contamination by industrial and municipal wastes. We must, on the other hand, make every effort to preserve the quality and purity of this vast water resource.

There are critical technical determinations to be made. And, although this conference is to be exploratory and fact-finding in nature, it should produce action not merely more reports, and it should result in the identification of specific pollution sources and a timetable for corrective action.

I urge the conferees to deliberate fairly, fully, and aggressively, and, if the evidence at hand is adequate, to make whatever hard choices must be made. Lake Superior is such a priceless asset that sound technical judgments must be wisely and promptly made.

Thank you.

(Applause.)

MR. KLEIN: Our third State which is represented in the conference today is the State of Michigan. Governor Milliken has

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asked his Administrative Aide, Mr. James Kellogg, to present his statement.

Mr. Kellogg. (Applause.)

STATEMENT OF THE HONORABLE WILLIAM G. MILLIKEN,
GOVERNOR, STATE OF MICHIGAN,
LANSING, MICHIGAN,
(READ BY JAMES KELLOGG,
ADMINISTRATIVE AIDE)

MR. KELLOGG: Thank you, Secretary Klein.

Governor Levander, Congressman Blatnik, conferees, ladies,
and gentlemen:

As many of you know, Governor Milliken has spearheaded the attack in Michigan on pollution, and with Governor Levander and other Governors is working now with the problem of DDT in the Upper Great Lakes region. He is unable to attend today because we have before our Legislature a \$335 million clean water bond which will hopefully be implemented today. He has asked me to read this statement in his behalf.

On behalf of the people of Michigan it is indeed a pleasure to address this conference on the preservation of the water quality of Lake Superior.

Lake Superior and all of the Great Lakes rank among the Nation's foremost resources. Indeed, no other territory on the face of the earth is simultaneously so well watered, so populous, and so highly urbanized, while cradling a vast agricultural, industrial,

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and recreation complex as the Great Lakes area.

Michigan and the Great Lakes are intricately intertwined in history, culture, and economy. Forty-one percent of the entire area of the Great Lakes lies within Michigan boundaries. Four of the Great Lakes form over 3,000 miles of Michigan shoreline.

The value, potential, and uniqueness of the Great Lakes are fully appreciated by the people of Michigan. We have more to gain or lose through the proper use or abuse of these waters than any other State. Today I wish to make it clear to this conference that Michigan will fulfill its responsibilities to ensure the preservation of these resources, will move rapidly in combating any water pollution, and will resist any unnecessary delay in executing present programs and meeting established goals.

Our concern and commitment have been underscored in a number of recent actions. Last November the citizens of Michigan approved a \$335 million bond issue to help finance local wastewater treatment facilities. At the same time approval was given for a \$100 million bond issue for the development of State and local outdoor recreation facilities. Our pollution control goal is to remove by 1980 the threat to our inland lakes, our rivers, and the Great Lakes by the construction of approximately 210 new treatment plants, the improvement of 126 existing sewage treatment plants, and the construction of sewers for an additional three and one-half million people. Two hundred eighty-five million dollars will be distributed as grants for treatment plant construction and \$50 million will be used to aid small, unsewered communities in the construction of sewer systems necessary to correct existing pollution.

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Our financing formula for the treatment plant and interceptor phase of the program was based on Federal legislation which provided for Federal assumption of 50 percent of the costs of eligible projects if the State would pay 25 percent. The Federal legislation also authorized the appropriation of funds by 1971 which would, as divided among the States by specified formula, have by then covered half the Federal Government obligation to Michigan computed project needs. Michigan bonding program is geared to 25 percent Federal financing by 1971 with the State to prefinance the other Federal 25 percent as well as paying its own 25 percent.

Unfortunately, Federal performance has not been forthcoming at a rate that will equal even one-half of the Federal promise. For example, in the upcoming fiscal year Michigan's share of the total amount authorized for this program would be roughly \$42 million, but it appears that less than \$8 million will be forthcoming.

I find it exceedingly difficult to understand the low Federal priority assigned to the sewage treatment works grant program when in referendum after referendum across the country the citizens of America have clearly demonstrated their very firm support for cleaning up our lakes and streams.

Moreover, new Federal legislative proposals have been put forward which would alter the basic legislation and change the ground rules under which the programs of Michigan and other States have been formulated. Clearly, this would represent a serious breach of faith with the States and, more important would delay effective pollution control immeasurably.

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Michigan with or without the Federal support promised will move ahead as rapidly as possible. It must be understood, however, that the tremendous potential of effective Federal-State-local partnership has not only been circumscribed in this program but will be increasingly difficult to invoke in any future programs.

Michigan has also acted to confront the whole spectrum of problems involved in the maintenance of environmental quality. By executive order, I have recently created a Council on Environmental Quality. The Council shall evaluate existing policies and programs and recommend new ones to deal with such urgent matters as solid waste disposal, air pollution, noise pollution, and other problems. The Council's chairman, who I am sure is well known to many of you, is Loring F. Oeming, who recently retired as the Executive Secretary of the Michigan Water Resources Commission.

The pesticide threat has recently received wide attention. Only three weeks ago the Governors of the Upper Great Lakes States met in Chicago at my request and reached agreement on a number of proposed actions. In Michigan we have initiated action to cancel the registration of DDT for sale and shipment within our State, the first State in the country to do so. The role and environmental effects of other pesticides must be reexamined in detail. I have instructed the Environmental Quality Council to make their first matter of business the preparation of a comprehensive pesticide plan for the State of Michigan.

These actions indicate the depth and degree of our concern for the maintenance of environmental quality. In regard to the specific subject of this conference, Lake Superior, we are fully

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committed to the preservation of the outstanding quality of this body of water. Our highest use designations and most stringent standards have been applied to Lake Superior. Furthermore, it is the established policy of the Michigan Water Resources Commission to prevent the impairment of all high quality waters in the State.

Our standards, with the exception of temperature criteria, and our plan of implementation have received the approval of the Secretary of the Interior and programs of corrective action have been initiated where required. Frankly, we are surprised that changes in the standards are being suggested at this time. If concrete results in terms of the construction of physical facilities adequate to prevent water pollution are to be achieved, the establishment of standards must be followed by a reasonable period of program implementation. Changes in existing standards will necessitate the suspension of present enforcement and construction programs while the process of adopting new standards is followed. Relative to the total program, we strongly question the desirability of modifying existing standards at this time.

Finally, the actions agreed upon by this conference will have to be carried out largely within the capabilities of the individual States involved. Such actions and their timetables for implementation must be formulated with realistic recognition of State capability and, also, of the commitments under way in other parts of the various States. If high priority actions are advocated, priority funding, in particular Federal funding of authorized programs, must be satisfactorily provided for.

In closing, I wish to reaffirm Michigan's intention of moving ahead as rapidly as possible. We have sent highly qualified

Colonel Richard J. Hesse

conferrees to this conference and we wish you well in your deliberations.

Thank you.

(Applause.)

MR. KLEIN: Thank you, Mr. Kellogg.

Commissioner Dominick and I will be back to you later so that we do really find out what DDT is, what it does, and how it has been affecting us.

We have with us today from the Corps of Engineers
Colonel Richard J. Hesse.

Colonel Hesse. (Applause.)

STATEMENT OF COLONEL RICHARD J. HESSE

DISTRICT ENGINEER, U.S. ARMY CORPS OF ENGINEERS

ST. PAUL DISTRICT, ST. PAUL, MINNESOTA

COLONEL HESSE: Thank you, Mr. Secretary.

Governor Levander, Congressman Blatnik, Mr. Dominick,
distinguished conferrees:

I appreciate the opportunity to describe briefly to this conference the operations of the Corps of Engineers which may be germane to water pollution problems on Lake Superior, its peripheral harbors, and its tributary streams. On 23 February 1968 I presented a statement on this same subject at a hearing of the Minnesota Pollution Control Agency at the Duluth Arena, and my remarks today will follow the same theme of this previous statement.

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The Corps of Engineers maintains the federally-authorized Duluth-Superior Harbor, 3 harbors along Superior's north shore in Minnesota, and 14 harbors on the lake's south shore in Wisconsin and Michigan. Many of these harbors on Lake Superior are situated at the mouths of the rivers or streams which carry measurable amounts of suspended sediment and bed load which frequently cause shoaling in the harbors. At some harbors entrances a natural shoaling tends to occur due to a littoral drift of lake bed material. The propeller wash from heavily loaded lake vessels and tugboats also produces the shoaling of harbors. All of these factors contribute to the need for periodic maintenance dredging in these harbors by Corps of Engineers floating plant.

Dredging of harbors on Lake Superior may be accomplished by dipper or bucket-type dredges loading into scows, by hydraulic pipe dredges with disposal of dredged material in any available authorized area on shore or in the lake, and by use of hopper dredges with disposal in the lake or pump out on shore. For the past 40 years disposal of the greater part of the material dredged from the harbors in Lake Superior has been in authorized deep water areas in the lake. Use of lake disposal is economically advantageous.

Deterioration of water quality in the lower Great Lakes, particularly in Lake Erie, has aroused considerable public concern and has prompted the Corps of Engineers to begin in 1966 on investigation of alternate disposal areas and the public benefits to be derived from the use of such areas for a number of Great Lakes harbors. At the request of the Bureau of the Budget, the Federal Water Pollution Control Administration joined the Corps of Engineers in this study to

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seek out alternate methods of disposal of dredged material, particularly such material which, if wasted in the lake, would have a cumulative detrimental effect on the lake's water quality. A detailed discussion of the methods and findings of this study would require more time than is available now, but suffice it to say that the Corps of Engineers, in conjunction with the Federal Water Pollution Control Administration and in cooperation with other interested Federal, State, and local officials, in constructing and maintaining the Lake Superior harbors has a guiding principle keeping the lake free of pollution at the least cost to the taxpayer. A public meeting to discuss this program is scheduled at Duluth on 20 May. Ultimately the U. S. Congress will decide such matters as cost sharing and the extent to which alternate methods of disposal will be used.

A second activity of the Corps of Engineers in maintaining the integrity of the navigable waters of the United States is the issuance of Department of the Army permits for dredging and the construction of all types of facilities in or adjacent to such waters. This practice of the Corps' issuing permits for work in navigable waters has been in effect for over 70 years. In considering such permits, the Corps of Engineers primary responsibility is the effect of the facility or work on navigation. However, the effect of other pertinent factors such as pollution, water quality, and fish and wildlife are also considered; and comments on the effect of the proposed work on public uses of the lake other than navigation are solicited by a public notice from all known interested parties, including local, State, and Federal authorities, and such comments are made a part of the record and are considered in determining

Colonel Richard J. Hesse

whether issuance of a permit would be in the best public interest.

In the summer of 1967 the scope of the Department of the Army permits was expanded by two Department of the Army directives. On 13 July 1967 the Secretaries of the Army and of the Interior adopted a Memorandum of Understanding which outlined policies and procedures for the discharge of the two Departments common responsibilities to improve water quality and to abate pollution in the navigable waters of this country. This Memorandum of Understanding specifies that the two Departments will exercise full cooperation and coordination in discharging their common responsibilities, and that District Engineers of the Corps of Engineers shall coordinate with the Regional Coordinators of the Department of the Interior in matters of fish and wildlife, recreation, and pollution associated with dredging, filling, and excavation operations authorized by Department of the Army permits.

On 21 July 1967 the Chief of Engineers directed that all Department of the Army permits for work in all navigable waters of the United States issued with more than the usual 3 year completion dates will be reviewed and revalidated periodically. The purpose of this directive is to insure that work authorized by permit and extending over a long period of time may be periodically reappraised to insure that the Federal interests in the waterways of the United States, including navigation, are adequately safeguarded.

In the light of this discussion, I wish to review briefly the current problem associated with the deposition by Reserve Mining Company, of taconite tailings into Lake Superior at Silver Bay,

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Minnesota. A Department of the Army permit was first issued to the Reserve Mining Company in April 1948 for the construction of a steel sheet pile dock, dredging within the harbor area, placing fill behind the dock face, construction of rubble mound breakwaters, and to deposit taconite tailings into Lake Superior, all at Silver Bay, Minnesota. On 12 August 1960 the time of completion of the dock and breakwaters as originally specified in the permit was extended to 31 December 1970. This extension of time was requested because the dock and breakwaters were designed for the ultimate capacity of the taconite processing plant, which would not be attained until 1970. On 30 September 1960, the Chief of Engineers approved an extension of time for the deposition of the taconite tailings into Lake Superior for an indefinite period because such deposition of tailings was anticipated over the entire life of the taconite processing plant. This extension of time for an indefinite period was qualified by the specific reservation that if the deposit of tailings from the processing plant in Lake Superior at any time shall cause an unreasonable obstruction to the free navigation in Lake Superior, the permittee shall remove any such deposition to such depth and within such areal limits as specified by the District Engineer without expense to the United States.

In accord with the directive of the Chief of Engineers dated 21 July 1967, my office issued on 1 November 1967, nearly a year and a half ago, a public notice to all known interested parties advising of the Corps' intent to revalidate for a 5-year period the Department of the Army permit issued to Reserve Mining Company. Two agencies of the Department of the Interior indicated that concentrations

Colonel Richard J. Hesse

of copper and zinc in Lake Superior adjacent to Silver Bay were of such magnitude to be of potentially serious concern to warrant further detailed study to determine the extent of this hazard. In conformance with the Memorandum of Understanding adopted by the Secretaries of the Army and Interior, various agencies of the Department of the Interior undertook, during the spring and summer of 1968, further field and laboratory studies in western Lake Superior to determine in some detail the effect of taconite tailings on fish and other aquatic life in the area adjacent to Silver Bay. A summary report on these studies was completed on 31 December 1968. Since that time this report has been under review in the office of the Secretary of the Interior. The Corps of Engineers does not propose to take any action in revalidating Reserve Mining Company's permit until the results of this conference become available and definitive recommendations are received from the Department of the Interior.

Thank you.

(Applause.)

MR. KLEIN: Thank you very much.

I will say the Corps of Engineers has adopted alternative methods in the Kenwood River region, which I had a little to do with in Illinois, and they have also adopted alternative methods around Lake Erie.

One of the big problems we have with dredging is that not always is it industry that is at fault. As a matter of fact, about 80 percent of the dredging in the Cuyahoga River in Cleveland came from siltation upstream. Until we can get the farmer to stop his fall plowing, which will reduce by 50 percent our siltation

Honorable Ben Boo

problem, we will continue having this problem. Not only is the Corps of Engineers and the Department of the Interior but the Department of Agriculture is now working on siltation or sedimentation traps in the Cuyahoga region so we can get over the need of having to do this dredging and having to deposit the dredge spoils some place.

We have with us today also Mayor Ben Boo of Duluth.

Mayor Boo. (Applause.)

STATEMENT OF THE HONORABLE BEN BOO, MAYOR,
CITY OF DULUTH, MINNESOTA

MAYOR BOO: Congressman, Mr. Klein, ladies and gentlemen:

The city of Duluth does not consider itself qualified to address itself to the problems created elsewhere in the lake, but we do want to enter for the record the progress made by the city of Duluth in the interests of clear water.

INTRODUCTION

The following is a statement of recent actions taken by the city of Duluth to reduce water pollution in the St. Louis River and Lake Superior, a statement of further actions planned in the near future to further reduce pollution of said waters, and a statement requesting designation of a single Federal agency to provide enforcement and control over the dumping of liquid and solid wastes from domestic and international vessels using Lake Superior and the

Honorable Ben Boo

Duluth-Superior Harbor. In addition, there are brief comments regarding the quality of Duluth water supply and the quality of the water in St. Louis River.

DISCONNECTION OF DOWNSPOUTS

On August 12, 1968, the City Council of Duluth passed a resolution requiring disconnection of all rain leaders, downspouts, and rain conductors on any premises within the city of Duluth which are connected to the city sanitary sewer system. Following a door-to-door inspection, approximately 1,950 letters were mailed to property owners on March 1, 1969, notifying them to disconnect rain leaders, downspouts, and rain conductors from the sanitary sewer system. The second inspection to determine compliance to date is presently in progress. Completion of this project is expected to substantially reduce flows to the city's four treatment plants, thus improving the quality of treatment.

ELIMINATION OF COMBINED SEWERS AND SEWER BYPASSES

Much work has been done during 1968 to correct and separate storm water from the sanitary sewer system in the Coffee Creek area. This was done by city of Duluth personnel and meant the elimination of a large volume of creek water from entering the sanitary sewer system. Previous to this, some sanitary waste was being discharged into Coffee Creek, thus necessitating treatment thereof.

Another project to alleviate wastewater overflows in the east end of the city was the building of a new lift station and an interceptor sewer from 34th Avenue East to 52nd Avenue East. This

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consisted of 7,600 feet of 30-inch RCP gravity sewer and 3,300 feet of 12-inch C. I. force main. The new lift station was built at 52nd Avenue East and Dodge Street. The total project cost was \$275 million. Previous to this construction the lift station at 60th Avenue East and the lake front was overtaxed and some bypassing of the flow was taking place. Construction of a pumping station and appurtenances at Lake Avenue and the Aerial Bridge and construction of a pumping station and appurtenances at 23rd Avenue East below Water Street (Lake front) are planned upon receipt of a Federal grant for a part of the cost thereof. This work will eliminate sewage flows into Lake Superior.

Included in the same application for Federal grant funds are plans to construct sanitary and storm sewers to accomplish sewer separations at the following locations: Central Avenue from Elinor Street to Columbia Avenue; Wadena Street from 49th Avenue West to 54th Avenue West; and 30th Avenue West to 28th Avenue West from Superior Street to 4th Street. Construction of these facilities will eliminate all significant combined sewers in the city.

SERVICE TO UNSEWERED AREAS

The city has entered into an agreement with the Minnesota Air National Guard to provide for extension of a trunk sewer line to serve the Air National Guard and the city's passenger terminal at the Duluth-Superior International Airport. Both facilities are presently served by inadequate treatment facilities. The city has also entered into an agreement with the town of Herman to permit connection to city sewers of unsewered properties along Trunk Highway No. 53 outside the city limits. Construction of these

Honorable Ben Boo

connecting sewers is expected this summer and fall. The previously mentioned Federal grant application also contemplates extension of a trunk sewer into a part of the Bay View Heights area of Duluth which is presently served by private septic tanks.

TREATMENT WORKS CONSTRUCTION

The most significant plan for action in the near future relates to proposed additions to and new construction of sewage treatment works. The firm of consulting engineers Black and Veatch, Kansas City, Missouri, in a preliminary report to the city has recommended a plan estimated to cost in excess of \$5 million to provide secondary and tertiary treatment of wastes at the city's main and three subsidiary treatment plants. The Duluth City Council has indicated the intent of the city, by resolution adopted March 24, 1969, to implement these plans and to complete construction of treatment works by June 18, 1972. It is the intent of the city to construct capacity in these treatment works to serve major Duluth industries not now served if it is mutually determined that this method is economically more feasible than separate treatment works construction and operation.

DUMPING OF SOLID AND LIQUID WASTES IN LAKE SUPERIOR AND THE

DULUTH-SUPERIOR HARBOR

The dumping of liquid and solid wastes from domestic and international vessels engaged in shipping through Lake Superior and Duluth-Superior Harbor is a matter of continuing concern from the standpoint of this practice resulting in a nuisance, unsightliness, damage to shoreline properties, a danger to smaller vessels, and, under some circumstances, a danger to public health. Several Federal

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agencies and Departments have an interest in this matter, each for a limited purpose related to their basic responsibilities, but none of these Federal agencies apparently has the authority, responsibility, or enforcement capability to cope with the total problem. Local regulation and enforcement is made difficult by reason of the State boundary falling within the St. Louis River and the Duluth-Superior Harbor. Enforcement by local authorities on the vast area of Lake Superior is impractical. It is our recommendation that the Department of the Interior take the lead in this matter by calling high ranking representatives of the other Federal agencies involved into a conference to reach agreement on the designation of a single Federal enforcement agency which would be empowered to cope with the problem rather than its individual aspects. The Federal agencies participating in this conference should include but not necessarily be limited to the following: the Department of Agriculture, the Coast Guard, Customs, and the Corps of Engineers.

DULUTH'S WATER SUPPLY

No change in the excellent quality of Duluth's water supply has been detected in the past 12 years, indicating an excellent water as measured by all water quality parameters.

Analytical methods to determine quality and compliance with requirements of United States Public Health Service drinking water standards are those specified in the current edition of Standard Methods for Examination of Water and Waste Water.

WATER QUALITY IN THE ST. LOUIS RIVER AND DULUTH-SUPERIOR HARBOR

For the past several years the city of Duluth has been testing water samples for bio-chemical oxygen demand and dissolved

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oxygen at five locations from the Trunk Highway No. 23 bridge over the St. Louis River to the Aerial Lift Bridge. Between these two points the effluent from the city's four treatment plants is discharged. In spite of all sources of pollution between the upstream and downstream sampling locations, the quality of the water as measured by B.O.D. and dissolved oxygen is better when it leaves the influence of the city than when it is received upstream. The results shown from the testing of these water samples has been placed on file with the Minnesota Pollution Control Agency.

With that I will submit this report to you, sir.

(Applause.)

MR. KLEIN: I have three telegrams which I will now read into the record.

The first is from Senator Hart. It reads as follows:

"The importance of preserving Lake Superior transcends even the need to protect the largest and purest of the Great Lakes. Superior is described as a delicate lake in which slightest change in its ecological balance can result in drastic damage. Therefore, we need vigilance to note even the smallest pollution threats and firmness to act against such threats. In final analysis, the fight to preserve Superior is a test of man's will to use his knowledge to protect a precious resource.

"If we succeed here, there will be hope that we have turned the corner on protecting our environment against our own abuses. If we fail, the biological time clock will have moved closer to midnight. As Chairman of the new Subcommittee on Energy, Natural Resources and Environment, I pledge my support in this most important

R. J. Higgins; K. F. Grittner, N. D. Coleman, V. K. Jensen

project. The appraisal of water pollution in the Lake Superior Basin offers 20 recommendations deserving serious consideration.

"I will appreciate your inserting my comments in the record, and will look forward to receiving a report of your most important conference."

Signed, Philip A. Hart, U. S. Senator from Michigan.

We have another telegram:

"Regret that legislative load prevents me from attending the conference. Be assured that we will support by the height of scientific evidence. Let cool heads rule the spirit of the conference.

"Best wishes for a successful meeting."

"Senator R. J. Higgins,"

We have another one:

"WHEREAS Lake Superior is an irreplaceable natural resource; and public has demonstrated its concern about the quality of water in Lake Superior;

"THEREFORE BE IT RESOLVED that the Minnesota Senate DFL caucus go on record urging the conferees of the enforcement conference meeting being held in Duluth May 13 to enhance the quality of the water by not permitting dumping of pollutants in Lake Superior."

Signed, Karl F. Grittner, Senate Minority Leader;
Nicholas D. Coleman, Assistant Minority Leader; V. K. Jensen,
Assistant Minority Leader.

At this point I shall stop the introductions of celebrities, of our Governors, Senators, and local mayors. We will get to the meat of the conference.

Dale S. Bryson

At this time may I reintroduce to you the Commissioner of the Federal Water Pollution Control Administration, Mr. David Dominick.

Commissioner Dominick. (Applause.)

MR. DOMINICK: Thank you, Mr. Chairman.

The Federal Water Pollution Control report is entitled "An Appraisal of Water Pollution in the Lake Superior Basin," and I request that it be entered into the record in its entirety.

(Which said report, entitled "An Appraisal of Water Pollution in the Lake Superior Basin," commences on page 67.)

Our presentation today will be divided into three parts, a general synopsis of that report, followed by several technical statements pertinent to the report and the FWPCA presentation will finish with the conclusions and recommendations.

Mr. Dale S. Bryson, Director of the Lake Superior Basin Office, will first present a general synopsis. He will be followed by several technical experts whom I will introduce at the proper time. Mr. Bryson will then present the conclusions and recommendations.

Mr. Bryson.

(Applause.)

STATEMENT OF DALE S. BRYSON, DIRECTOR,
LAKE SUPERIOR BASIN OFFICE, FEDERAL
WATER POLLUTION CONTROL ADMINISTRATION,
MINNEAPOLIS, MINNESOTA

Dale S. Bryson

MR. BRYSON: Thank you, Mr. Dominick.

Mr. Chairman, ladies and gentlemen:

The Great Lakes Region of the Federal Water Pollution Control Administration has prepared a report for the conferees to use in their consideration of what is needed to preserve the existing excellent quality of water and to improve waters that are presently degraded in the Lake Superior Basin. This report is based on studies and investigations by the Federal Water Pollution Control Administration, on reports by other bureaus of the Department of the Interior, on information obtained from other Federal agencies, from the Lake Superior States of Michigan, Minnesota, and Wisconsin, and from other sources. This report, entitled "An Appraisal of Water Pollution in the Lake Superior Basin," has been made available for general distribution and can be obtained in the lobby at the entrance of this conference room.

My statement will follow the general outline of the report, which contains background information and a description of the basin; a description of the major water uses and water pollution problems and a brief synopsis concerning water quality standards and proposed new water quality criteria. My statement will be concluded with the summary and recommendations. As Mr. Dominick said, my statement will be supported by separate presentations from various experts.

I would first like to invite your attention to the map on the wall. The area covered by this conference is outlined with the dotted line on the map representing the boundary of the Lake Superior drainage basin. This area is also shown in Figure 1 of the report. The total drainage area is approximately 80,000 square miles. Lake Superior is the largest freshwater lake in the world in terms of

Dale S. Bryson

surface area. In terms of volume of water, it is the world's second largest freshwater lake. Just less than half of the drainage basin lies within the United States. All data presented in this statement are for the United States portion of the Lake Superior Basin unless otherwise noted.

The population density of the United States portion of the basin is low, with the main concentration of people being in the western tip of the lake. The main population centers in the basin are as shown on the screen, which is Figure 2 of the report. While many people have emigrated from the Lake Superior Basin in the last 20 years, the population is expected to increase by approximately 100,000 people in the next 20 years.

The next slide, which is Figure 3 in the report, shows that industrial activity in the area is diversified both in character as well as location. Mining is the dominant industry in the watershed.

Recreation is very important to the economy and it is expected to have even greater significance in the future as more people from locations outside of the area seek to use existing and planned recreation facilities.

The next slide, which is Figure 4 in the report, shows the commercial harbor facilities around Lake Superior. These facilities are a major asset to the continuing development of the natural resources potential of the basin. The facilities of the Duluth-Superior Harbor, which, by the way, include the largest ore docks in the world, handle the majority of the iron ore shipped to the steel mills on the lower Great Lakes. Various commodities are

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shipped from the other commercial harbors shown on the figure.

There are well over 100 streams in the three States which outlet to Lake Superior. Information concerning the major streams is shown in Table 1 of the report.

In addition to the many streams, there are approximately 2,000 lakes of 10 acres or more within the basin.

The foregoing has been a brief description of the salient characteristics of the Lake Superior drainage area. I will now describe some of the more important water uses in the basin.

The waters of Lake Superior are of excellent quality for municipal water supply. Seventeen water systems withdraw water directly from the lake for domestic usage. Twelve of these 17 provide absolutely no treatment of the water other than chlorination before supplying the consumer. These systems serve approximately 170,000 people.

Over a billion gallons per day of water in the basin are withdrawn for industrial purposes. The largest single water user is the Reserve Mining Company taconite beneficiation plant at Silver Bay, Minnesota. This plant accounts for more than 25 percent of the total water used by industry.

Electric power generation in the Lake Superior Basin, including hydroelectric and stream generation, is an important water use.

Commercial fishing has always been a significant part of the economy of the basin. The commercial catch, however, has been declining in quantity and quality over the past few years due mainly to biological and economical factors. For example, lake trout, the most popular and valuable fish, have suffered the ravages of the

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parasitic sea lamprey such that the trout population almost ceased in Lake Superior. Indications are that the population of lake trout is now increasing.

The basin is an area of outstanding natural resources and great recreation potential. The vast majority of recreation activities in the basin are centered around or near water. These include boating, fishing, and those activities significantly enhanced by the presence of water, such as hiking, camping, sightseeing, and driving for pleasure. Even though it is recognized that recreationists participate in all the other basin activities in addition to sightseeing, it is the attraction of this latter activity which draws most recreationists to the basin. Probably Lake Superior's greatest asset is its scenic shoreline. The enjoyment of such a scene as this is priceless.

I would now like to discuss some general aspects of water pollution problems as they exist in Lake Superior.

One of the most important characteristics of Lake Superior from the standpoint of pollution is the movement of water within the lake due to currents. The importance of an understanding of currents in the lake has long been recognized. An investigation to establish the current patterns was conducted by the Great Lakes Region several years ago. It revealed that there is a general mixing of the waters throughout the lake.

A word that is used quite often in a discussion of lakes these days is the word "eutrophication." This word is often related to water pollution and water quality problems in a lake. In simplest

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terms, eutrophication means the aging process of a lake in which its waters become more fertile and acquire a greater capacity to grow algae and other forms of unwanted living matter. A quite fertile and therefore old lake is classified as a eutrophic lake. The opposite of an eutrophic lake is an oligotrophic lake. While there are a number of characteristics associated with oligotrophic lakes, in short, they are still biologically young and have changed little since the time of their formation. Lake Superior is an excellent example of an oligotrophic lake. The quality of water in Lake Superior surpasses that of virtually all other major lakes in the United States.

Continuing the discussion of water pollution problems, pollution by dissolved chemicals can cover a broad range of substances, including heavy metals, such as copper, iron and zinc, oil, colored waters, and nutrients, such as nitrogen and phosphorus. Two general types of effects are produced by such chemicals: 1) local and immediate effects in the vicinity of the source and; 2) a progressive buildup in the concentrations of certain persistent chemicals in the lake as a whole.

Lake Superior and Lake Michigan are the headwaters of the Great Lakes as their outflow passes through Lakes Huron, Erie, and Ontario. Constituents dissolved in Lake Superior waters, such as nutrients which tend to accumulate in a lake, could therefore add to the accumulated levels in these downstream lakes.

The three Lakes Superior States have addressed themselves to phosphorus removal as discussed in the main report.

The discharge of excessive amounts of oil and phenols has occurred at the United States Steel Company, Duluth Works, with notable

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examples in the Summer of 1968. The company also discharges excessive amounts of flue dust and fly ash from the blast furnace.

E. I. Dupont Company at Barksdale, Wisconsin, discharges its waste to Boyd Creek. The waste reaches Lake Superior causing a discoloration of the water.

Oxygen depletion is a water pollution problem that is occurring in the Lake Superior Basin. The small quantity of oxygen normally dissolved in water is one of the most important ingredients necessary for a healthy, balanced aquatic life environment. Dissolved oxygen is consumed by living organisms through respiration and is replenished, if a well-balanced environment exists, by absorption from the atmosphere and through the life processes of aquatic plants. When organic pollution enters this environment the balance is altered. The bacteria present in the water or introduced with pollution utilize the organic matter as food and multiply rapidly. Their use of oxygen may be great enough to inhibit or destroy the fish and other desirable organisms and to convert the stream or lake into an odor-producing nuisance. Generally, when these conditions prevail the esthetic value of the water resource will be impaired or completely destroyed.

At the present time the main body of Lake Superior has not shown any signs of oxygen depletion; in fact, the oxygen levels are at or near the saturation point at all depths of the lake.

Oxygen depletion is occurring in some of the interstate tributaries draining into Lake Superior. In the Minnesota drainage, reaches of the lower St. Louis River from Cloquet to the Duluth-Superior Harbor have on numerous occasions been excessively depleted of oxygen. Inadequately treated sewage effluent from Cloquet and

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several smaller communities and inadequately treated industrial wastes from Conwed Corporation and Northwest Paper Company in Cloquet discharged into this reach have been the source of the problem. The condition is aggravated by the operation of hydro-electric plants on the river which cause wide fluctuations in river flow.

Waster discharged into the Duluth-Superior Harbor have also created localized areas of substantial oxygen depletion. Sources of pollution include inadequately treated municipal wastes from the cities of Duluth and Superior, plus inadequately treated industrial wastes from Superwood Corporation and Superior Fiber Products Company.

The interstate Montreal River downstream from Hurley, Wisconsin, and Ironwood, Michigan, has experienced oxygen depletion problems. The proportion of the oxygen depletion caused by the waste discharges from each of these two cities has not been determined.

Under the provisions of interstate water quality standards the State regulatory agencies have initiated action to eliminate the oxygen depletion problems occurring on the tributary streams.

Bacterial pollution is a problem in certain areas of the Lake Superior Basin. The bacterial quality of the main body of Lake Superior is excellent. The problems of bacterial contamination that have occurred are along certain interstate tributaries and some harbor areas around the lake. Discharges from Cloquet, Carlton, Scanlon, and Duluth have caused bacterial contamination in the St. Louis River; discharges from Duluth and Superior have caused

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bacterial contamination in the Duluth-Superior Harbor; discharges from Ashland and Bayfield have caused bacterial contamination in the inshore areas; and discharges from Hurley, Wisconsin, have caused bacterial contamination in the Montreal River.

Bacterial pollution is amenable to correction. This is the case whenever the waste can be put through a treatment plant and then disinfected. The State regulatory agencies have started action to eliminate existing bacterial pollution problems and to prevent future undesirable conditions.

Soil erosion is a serious pollution problem in a large portion of the south shore of Lake Superior. This area, commonly called the red clay area, experiences severe erosion problems with the sediment creating an adverse water quality problem in the streams and in the lake itself. These problems have been recognized by interested Federal, State, and local agencies and are currently under investigation. The Red Clay Interagency Committee, comprised of Federal, State, and local representatives, issued a report in 1967 which identifies the sources and causes of erosion and proposed an action plan for corrective measures.

To place the problem of soil erosion into proper perspective, the Federal Water Pollution Control Administration has estimated that the sediment load carried to Lake Superior in 1 year by all the United States tributaries is equal to 12 days of discharge from Reserve Mining Company.

Another pollution problem in the Lake Superior Basin is caused by wastes from watercraft. Vessels of all types -- commercial,

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recreational, and Federal -- plying the waters of Lake Superior and its tributaries are contributors of both untreated and inadequately treated wastes. This waste is discharged in local harbors and in the open lake and tends to intensify local pollution problems.

Certain aspects of water pollution from watercraft have been documented in the report "Wastes From Watercraft," prepared by the Federal Water Pollution Control Administration, and submitted to Congress in 1967. The report recognizes and analyzes the serious pollution problems that are caused by all types of watercraft, including pollution by sewage, garbage, and oil wastes. Implementation by the Federal Government of the recommendations made in this report can provide an effective means for combatting the vessel pollution problems of Lake Superior. The Department has proposed legislation to Congress based on this report. A summary of applicable state laws dealing with vessel pollution are presented in the main report.

Oil pollution to date has not been a significant problem in the Lake Superior Basin. While relatively minor problems resulting from oil have occurred, the basin has escaped the effects of a major spill. Steps have been taken, however, to insure that a coordinated response of effort among Federal, State, and local agencies will occur in the event of a major spill. A national multi-agency contingency plan for responding to major polluttional spills was approved by the President on November 13, 1968. A contingency plan for Lake Superior has been developed in accordance with provisions of the national plan by the Great Lakes Region of the Federal Water Pollution Control Administration. The purpose of this plan is to present

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guidelines to minimize the polluttional effects of a major spill of oil or other hazardous materials. The plan's objectives are to develop effective systems for discovering and reporting the existence of a pollution incident, promptly instituting measures to restrict the further spread of the pollutant, applying techniques to clean up and disperse the collected pollutants, and instituting action to recover cleanup costs and effect enforcement of existing statutes. In recent years attention has been directed to the problem of the disposal of polluted dredged materials in the open waters of the Great Lakes. The Federal Water Pollution Control Administration is concerned about the long term cumulative effect of incremental additions of this polluted material to the lakes. Dredged material can range from clean lake sand to sediments which are seriously polluted by industrial and municipal wastes. The dredgings may contain oil and grease, dissolved solids, nutrients, and toxic materials.

As Colonel Hesse pointed out, responsibility for improvement and maintenance of the waterways of the United States in the interest of navigation has been delegated by acts of Congress to the Corps of Engineers. In carrying out this responsibility the Corps dredges approximately 300,000 cubic yards per year in Lake Superior. This is conducted in some of the commercial harbors shown in Figure 4 of the report and in some small boat harbors maintained by the Corps of Engineers. During the past 2 years the Corps of Engineers and Federal Water Pollution Control Administration have been carrying out a joint study of water quality problems associated with dredging in the Great Lakes. A report of findings is now available for perusal

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at the Corps's district offices and various other locations.

Results of limited sediment analysis by the Federal Water Pollution Control Administration in Lake Superior Harbors indicate the presence of polluted materials in certain areas of Duluth-Superior and Ashland Harbors. The analysis showed the sediment contained unacceptable levels of oil and grease, phosphorus, and chemical oxygen demand. The Federal Water Pollution Control Administration will continue to assist the Corps by classifying harbor sediments as to their suitability for open lake disposal. It is suggested the Corps continue its program of developing alternate disposal areas for polluted sediments.

Pesticide levels have been the subject of interest of late in the Great Lakes. Concentrations of insecticides are lower in the fishes of Lake Superior than in the fishes of any other of the Great Lakes, according to data furnished by the Bureau of Commercial Fisheries. Compared to similar species from Lake Michigan, Lake Superior fish have $1/7$ to $1/4$ the amount of DDT and $1/7$ to $1/2$ the amount of dieldrin.

The persistent insecticides must be kept from entering Lake Superior. If they do accumulate there, the damage will be apparent for a long period of time due to the slow flow-through time of the lake. Less insecticide need be added to the waters of Lake Superior before unacceptable amounts will occur in the important fishes such as lake trout. The reason is lake trout is a long-lived predatory species and therefore is an efficient accumulator of insecticides.

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A technical committee on pesticides was established as part of the Lake Michigan enforcement conference to evaluate the pesticide problem in Lake Michigan and to recommend to the conferees a program of monitoring and control. The committee determined that controls should be instituted to insure that the concentration of various insecticides do not increase above existing levels in Lake Superior as there are no indications of harm in Lake Superior fish resulting from the existing levels.

Indications are that uses of insecticides in the Lake Superior Basin are at relatively low levels. Even with a low usage, insecticides are being concentrated in fish and underline the importance of caution and surveillance to avoid a future problem.

Federal installations in the Lake Superior Basin are a source of waste. These installations are listed in the appendix to the main report and vary in size from those having pit type toilets in recreation areas to large treatment facilities at Air Force installations. A coordinated effort to get the Federal house in order is being made under the impetus of Presidential Executive Order 11288, which directed heads of Federal activities to provide leadership in the nationwide water pollution control program. This Executive Order also applies to Federal watercraft, to Federal water resources projects, and to facilities supported by Federal loans, grants, and contracts.

Mining operations in the basin have caused water quality problems. A general discussion of these is found in the main report.

One aspect of the mining industry that has received attention is the Reserve Mining Company E. W. Davis Works which discharges its waste tailings directly to Lake Superior. In 1968

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agencies within the Department of the Interior established a study group to investigate the effects of taconite tailings on Lake Superior. Based on data gathered by the individual agencies comprising this study group and on the basis of information contained in other reports, certain conclusions were reached. These conclusions are presented on Pages 27 and 28 of the main report.

As was pointed out earlier in this statement and as discussed in the main report, the quality of water in Lake Superior surpasses that of virtually all other major lakes of the United States. The low dissolved and suspended solids, the very cold temperatures, the extreme clarity and the high oxygen concentration of the waters, coupled with the size of the lake, makes a unique natural resource that has no equal in the world.

Under the provisions of the Water Quality Act of 1965 the States of Michigan, Minnesota, and Wisconsin have adopted water quality standards for Lake Superior. The States assigned their highest use categories to Lake Superior, those being public water supply, whole body contact recreation, and cold water fishery. The water quality criteria adopted to protect these designated uses were established using the best available knowledge at that time. Hence, the water quality standards established for Lake Superior are among the most stringent standards nationally.

In accordance with the provisions of the Water Quality Act of 1965 it was anticipated that after the initial setting of standards, periodic review and revision of water quality standards would be required to take into account changing technology and advances

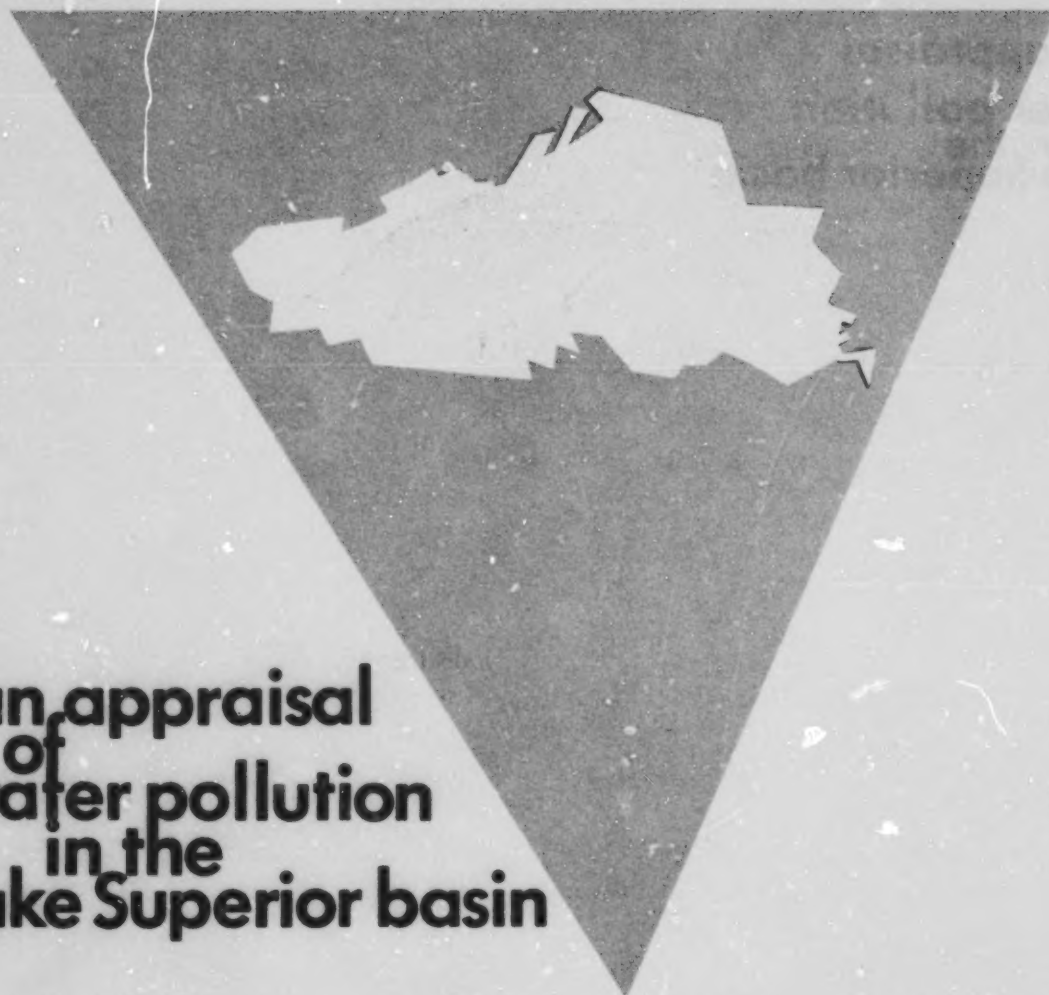
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in knowledge of water quality requirements developed through research. Additional data concerning water quality criteria specific to Lake Superior waters are now available as a result of recently completed research at the Federal Water Pollution Control Administration National Water Quality Laboratory at Duluth. The National Technical Advisory Committee on Water Quality Criteria provides additional information that is applicable to these waters.

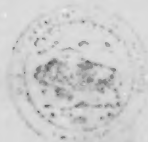
On the basis of this new knowledge water quality criteria can be developed on the open waters of Lake Superior to reflect more appropriately the uniqueness of the lake. These criteria are presented in Table 3 on Page 44 of the report.

Mr. Chairman, that concludes my statement. I would be glad to answer any questions now, or we could move right into the supplemental statements of the various experts.

(No response.)



**an appraisal
of
water pollution
in the
lake Superior basin**



**U. S. Department of the Interior
Federal Water Pollution Control Administration
Great Lakes Region**

APRIL 1969

**an appraisal
of
water pollution
in the
lake Superior basin**

APRIL 1969



U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION

FOREWORD

"Lake Superior is apart from the other Great Lakes - it is the storied 'Shining Big Sea Water,' the symbol, the spirit of an intrinsic part of the [American] heritage. To those individuals fortunate enough to have witnessed the crashing of great seas on age-old rock, or the chilling, quiet blanket of fog suddenly lifting to the near blinding of a blue-white summer day; to have seen water so clear that the phantom trout were visible at 5 fathoms; to have experienced the purity that is the Big Lake - to them there is no need to justify any conservation effort on behalf of Lake Superior."

Adapted from Michigan Water Resources Commission
"Water Resource Uses, Present and Prospective
for Lake Superior and the St. Mary's River,"
June 1967

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I. INTRODUCTION

On the basis of reports, surveys and studies indicating that interstate pollution is occurring, and in accordance with Section 10 of the Federal Water Pollution Control Act (33 U. S. C. 466 et. seq.) Secretary of the Interior Stewart L. Udall called a Conference in the Matter of Pollution of the Waters of Lake Superior and Its Tributary Basin (Michigan-Minnesota-Wisconsin). The area covered by the conference is shown on Figure 1.

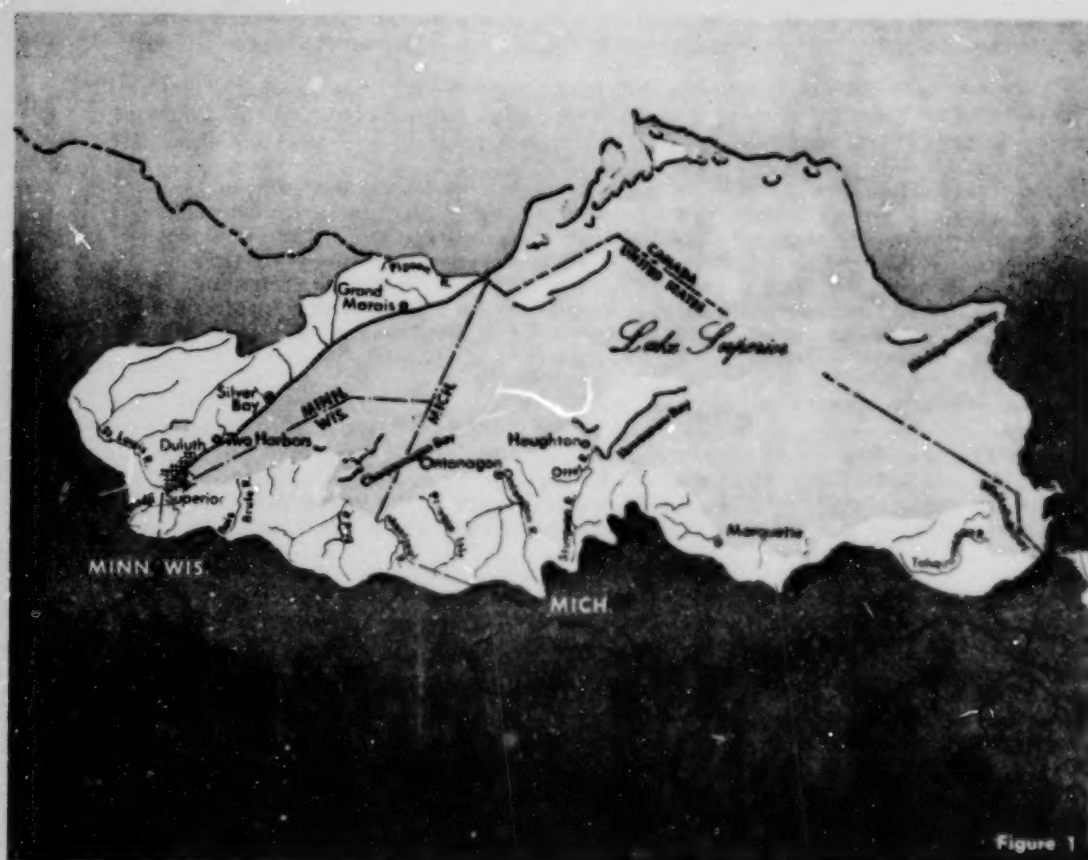
This report was prepared for the information of the conferees and other interested parties, and for use by the conferees in their consideration of actions needed to preserve the high quality of waters in the conference area and improve presently degraded waters. The report is based on studies and investigations by the Federal Water Pollution Control Administration (FWPCA), investigations made through cooperative agreements by other agencies of the Department of the Interior, studies and reports furnished by the three Lake Superior States and information obtained from other Federal agencies, universities, and others. All data presented in this report are for the United States portion of the Lake Superior basin, unless otherwise noted.

The contributions of all who have provided assistance and information is gratefully acknowledged.



Scale: 50 0 50 100 miles

LAKE SUPERIOR BASIN



II. THE BASIN AND ITS FEATURES

GENERAL DESCRIPTION

The largest body of fresh water on the earth is comprised in the five Great Lakes covering 95,170 square miles water surface area. Lake Superior is the largest of the Great Lakes and the largest lake in the world - 31,820 square miles in surface area, approximately 350 miles long, 160 miles wide, 1,333 feet maximum depth, and a volume of approximately 3,000 cubic miles. Other physical data concerning Lake Superior are shown on the following table.

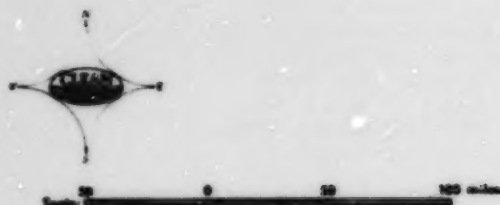
	<u>Total</u>	<u>Canada</u> <u>(Ontario)</u>	<u>United</u> <u>States</u>	<u>Mich.</u>	<u>Minn.</u>	<u>Wisc.</u>
Drainage Basin (sq. mi.)	80,511	42,570	37,941	23,931	8,354	5,656
Water Surface (sq. mi.)	31,820	10,702	21,118	16,231	2,212	2,675
Land Area (sq. mi.)	48,691	31,868	16,823	7,700	6,142	2,981
Shoreline (miles)	2,976	1,549	1,427	913	189	325

The topography of the basin, in general, is rough and with certain exceptions, the lake is surrounded by a ridge 400 to 800 feet high. In most areas the highland is either immediately adjacent to the shoreline or close to it. The Wisconsin-Michigan area along the southern shore rises less abruptly, but the height of the ridge is about the same as in Minnesota.

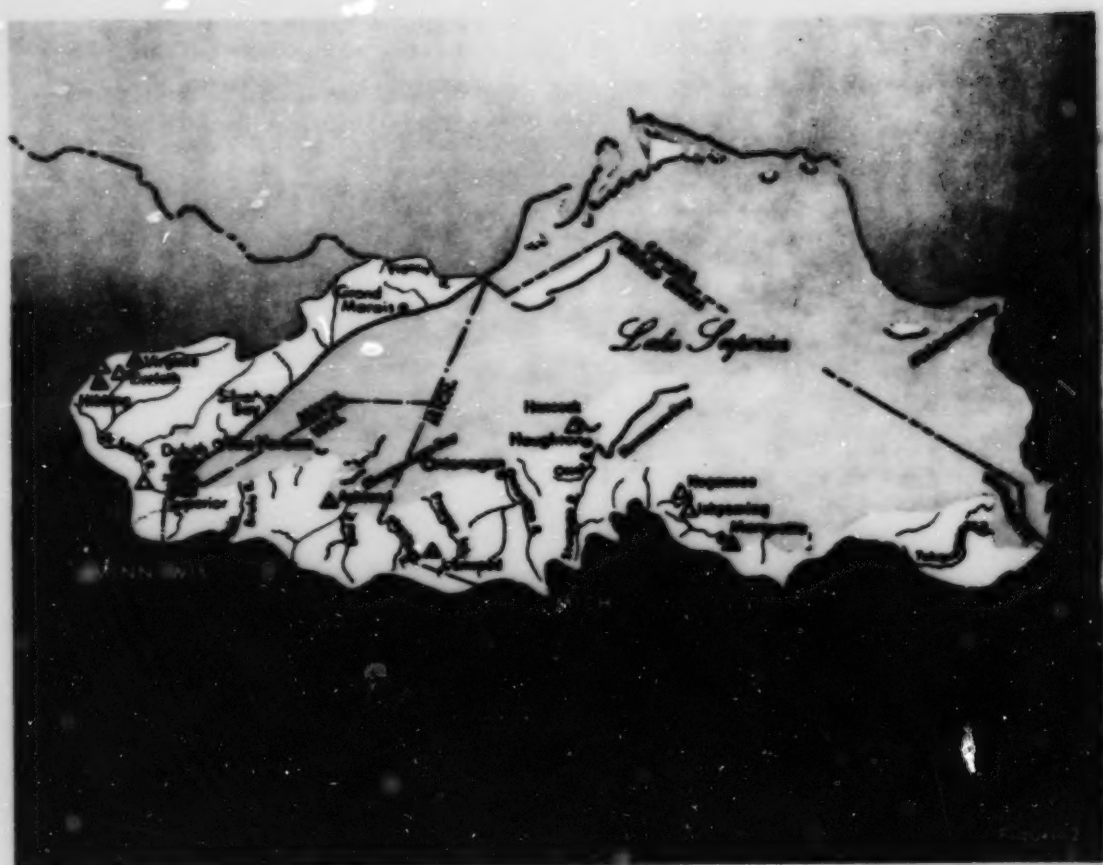
The soil has developed from glacial debris and shallow-lying bedrock. It is a mixture of sand and sandy loam to clay. The low soil fertility and the short growing season are not favorable for extensive agricultural activities.

The climate of the basin is continental in the interior, while a modified marine climate is found near the lake shore and particularly in the peninsular areas. These two distinct types of climate are reflected in the temperatures, precipitation, and growing seasons. Extreme temperatures range from -47°F. to 106°F., while the basin's average temperatures range from 8°F. to 12°F. for January, and 60°F. to 66°F. for July. The average annual precipitation is 28 to 32 inches with 16 to 19 inches falling during the warm season. Snowfall varies from 55 inches to 276 inches in different portions of the basin, and the growing season, which also reflects the wide climate range, varies from 80 to 130 days in the basin.

The principal river of the basin is the St. Louis which has a drainage area of about 3,700 square miles and is an interstate stream that forms part of the Minnesota-Wisconsin boundary. A portion of the Michigan-Wisconsin boundary is formed by the interstate Montreal River, one of the smaller streams in the basin draining an area of about 281 square miles. The boundary between Minnesota and the Province of Ontario, Canada, is formed by the Pigeon River. Other principal rivers are the Bad River in Wisconsin and the Ontonagon River in Michigan.

**POPULATION CENTERS****LEGEND:**

- 100,000
- 20,000 - 50,000
- ▲ 10,000 - 20,000
- △ 5,000 - 10,000



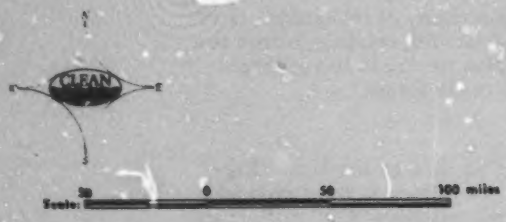
POPULATION

The population density in the United States portion of the basin is low, 30 people per square mile. Approximately a half-million people live in the basin with Minnesota counties (primarily St. Louis County) accounting for about half of the total population. Michigan and Wisconsin counties account for about 34 percent and 16 percent, respectively. The major cities in the Lake Superior watershed with their 1960 populations are: Minnesota, Duluth - 106,884, Hibbing - 17,731, and Virginia - 14,034; Wisconsin, Superior - 33,563, Ashland - 10,132; Michigan, Marquette - 19,824 and Ironwood - 10,265. Figure 2 shows these population centers.

Even though during the past 20 years there has been a considerable emigration from the Lake Superior basin, the population is expected to increase by approximately 100,000 in about two decades with the municipal portion of the population experiencing most of this increase at the expense of the rural areas. The areas most likely to show relatively rapid growth are: Chippewa and Marquette Counties in Michigan, Douglas County in Wisconsin, and St. Louis County in Minnesota. Carlton and Lake Counties, which border on St. Louis County, will experience some of the expansion trend of that county.



Duluth, Minnesota at the head of Lake Superior is the largest city in the basin.



INDUSTRIAL CENTERS

LEGEND:

- | | |
|--------------------------------|-------------------------------|
| ① Food and kindred products | ⊙ Petroleum and coal products |
| ② Paper and allied products | Ⓜ Primary metal industries |
| ③ Chemical and allied products | Ⓜ Metal mining |

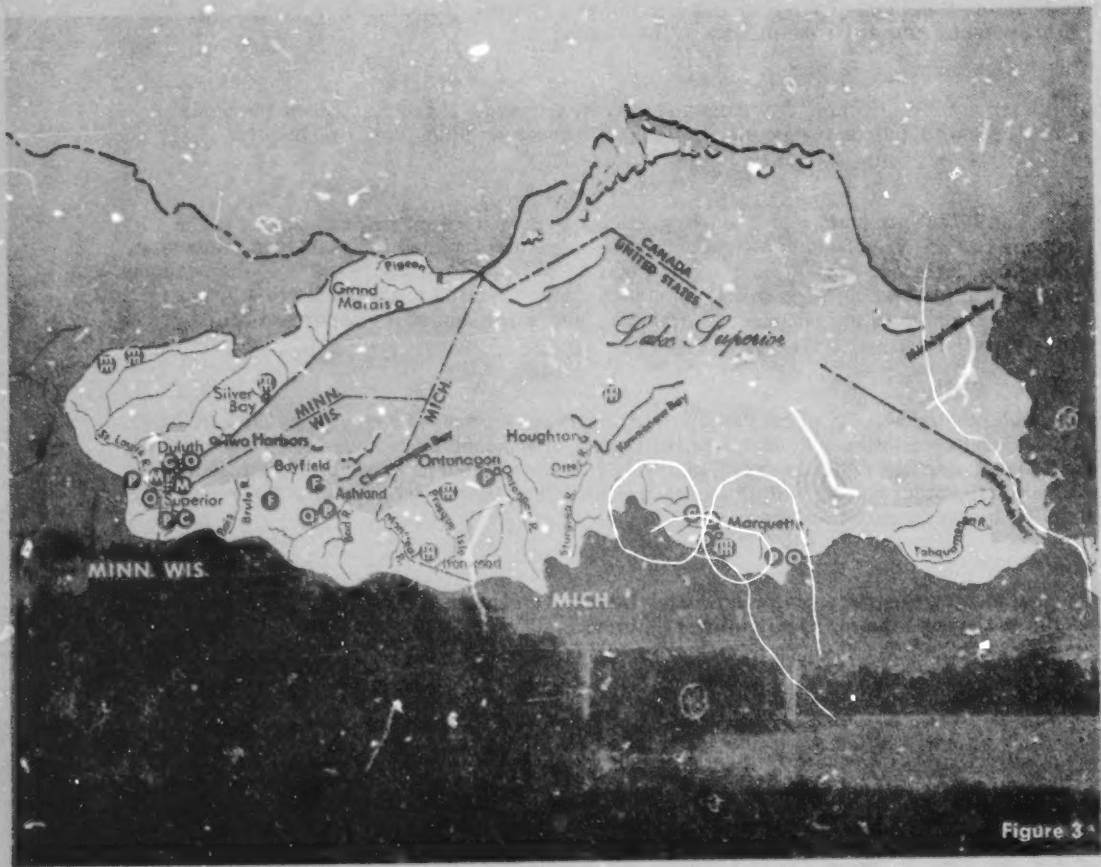


Figure 3

ECONOMY

While the economy of the basin has in the past few decades been uncertain, developments in recent years favor a general uptrend in activity. Continued research activities relating to iron ore processing, dramatic developments in processing of taconite ores, plus progress in research concerning the use of timber resources is creating a new confidence in the future.

Industrial activity in the watershed is diversified both in character as well as location. Figure 3 shows the principal centers of industrial activity. While iron ore mining is the dominant feature of the watershed, value added by manufacture amounted to approximately \$250 million in 1963. Duluth - Superior is the major industrial center, but, significant industrial developments are located elsewhere, such as Silver Bay, Minnesota; Ashland, Wisconsin; and Houghton-Hancock, Michigan.

The history of iron ore mining is closely associated with the development of the iron range area of the basin. With the advent of the taconite process whereby low grade iron ore undergoes a beneficiation process to produce pellets containing a higher concentration of iron, the iron mining industry in the basin has economically taken a sharp upturn. As of 1960 pelletized iron ore was firmly established as the most desired form of blast furnace feed in the United States. Taconite beneficiation plants have been established at a number of locations in Minnesota, Michigan, with a potential for their establishment in Wisconsin.

Other mining activities, primarily sand and gravel, are widespread throughout the basin. Copper mining is an important segment of Michigan's economy in the upper peninsula.

Forestry and forest products manufacturing are important in a number of locations in the Lake Superior basin. Virgin timber stands have been greatly depleted but sustained lumbering, pulp logging and Christmas tree harvesting continue to be important contributors to the economy. New technology in processing wood products should enable the area to capitalize to a greater degree on the extensive forest resources. Considerable expansion of the paper and allied products industry is likely.

Some manufacturing activity occurs in all counties of the watershed although in 1963 St. Louis and Carlton Counties of Minnesota and Douglas County in Wisconsin accounted for 70 percent of the total. Manufacturing output is expected to triple in the next 20 to 25 years. Petroleum refining, chemicals, steel rolling and finishing, and food and kindred products are the major categories having installations within the watershed.

Although agriculture is not a major land use, farms are scattered throughout the basin and in some limited areas farming is a dominant feature.

Some of the Nation's most unique and scenic shoreline is a part of the Lake Superior coast line. The wide sand beaches of Whitefish Bay, the great perched dunes near Grand Marais, the sheer cliffs of the Pictured Rocks, the remoteness of the Huron Mountains, the Apostle Islands, Split Rock Lighthouse, Isle Royale National Park and all the many miles of primeval wilderness constitute a most valuable recreation and esthetic resource. Therefore, recreation resources including commercial resorts are very important to the economy and are expected to have even greater significance in the future as a greater number of people from locations outside of the area seek to utilize its existing and planned recreation facilities. An estimated \$50 million was spent in the basin on tourism in 1964 (44). It can be assumed this is a conservative figure based upon estimates of growth for the tourism industry.



The use of high quality water extends beyond the bounds of physical contact with the resource. Here towering cliffs and spectacular shoreline provide scenic enjoyment.

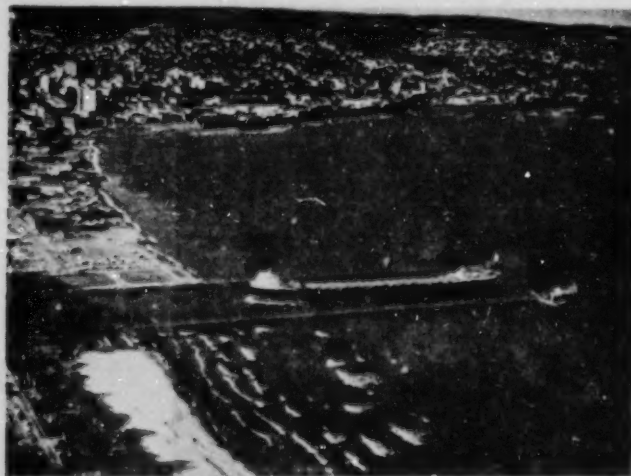
WATERBORNE COMMERCE

The economy of the Lake Superior basin is naturally stimulated by the presence of the lake. The "fourth seacoast" of the United States and Canada became a reality upon completion of the St. Lawrence Seaway in 1959. There is now a continuous channel from the Great Lakes to the Atlantic Ocean making an ocean port of every deep draft harbor situated on Lake Superior.

The Soo Locks at Sault Ste. Marie and navigable channels of the St. Mary's River are of major importance to commercial navigation in Lake Superior. This busy channel passes approximately 100 million tons of freight annually. With the deep connecting channels and harbors and the new lock (1,200 feet long, 105 feet wide) at Sault Ste. Marie, vessels 1,000 feet in length and 100 feet wide with carrying capacities of 50,000 tons can now be accommodated. Major commodities shipped include iron ore, coal, grain and stone.

The harbor facilities of Lake Superior are also a major asset to the continuing development of the natural resources potential of the basin. The Duluth-Superior port is one of the largest inland shipping ports for waterborne commerce on the Great Lakes. The harbor is the fifth largest in the United States in tonnage, surpassed only by New York Harbor, New Orleans, Houston Harbor and Channel, and the Philadelphia Harbor. Total tonnage exceeds 46 million net tons annually. Annual direct overseas imports and exports total over 3 million tons and consist of more than one-third of the direct overseas commerce from all Great Lakes ports. The facilities of the Duluth-Superior harbor, which include the largest ore docks in the world, handle the majority of the iron ore which is shipped to the steel mills of the lower lakes. Approximately three-fourths of the total tonnage at the port consists of iron ore. Other major commodities are grain, coal, limestone, cement, scrap iron, iron and steel products, salt, petroleum products, and general merchandise.

In addition to the outstanding facilities at Duluth-Superior there are other commercial harbors throughout the area, including Two Harbors, Silver Bay, Taconite and Grand Marais in Minnesota; Ashland in Wisconsin; and Ontonagon, Keweenaw, Presque Isle, Marquette and Grand Marais in Michigan. Figure 4 depicts the commercial harbors on Lake Superior.



Facilities of the Duluth-Superior Harbor include the largest ore docks in the world. Above is an ore boat entering the harbor.



Scale: 0 50 100 miles

COMMERCIAL HARBORS

LEGEND:

■ Harbors

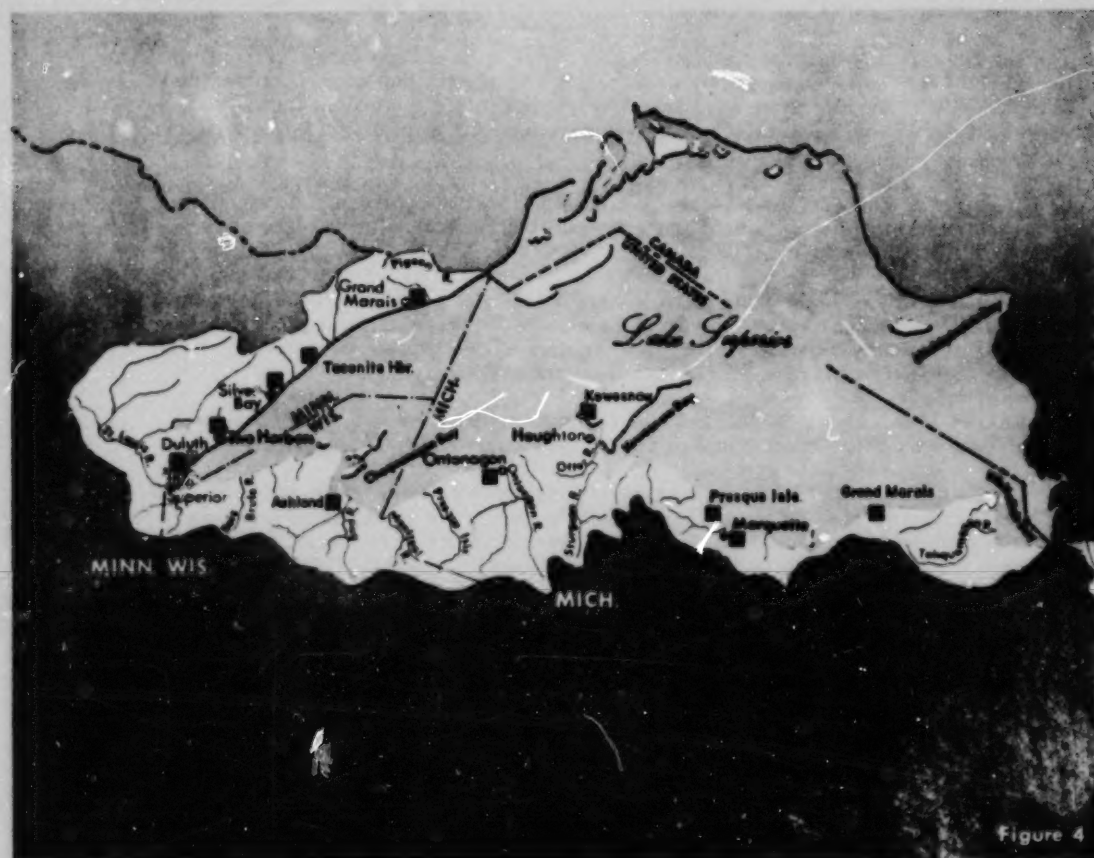


Figure 4

WATER RESOURCES

Lake Superior is the largest of the Great Lakes and in terms of surface area is the largest fresh water lake in the world. In terms of volume of water it is the world's second largest fresh water lake. The average flow out of Lake Superior is 73,100 cubic feet per second (cfs).

Since 1922 the level of Lake Superior has been regulated by operations of control works in the St. Mary's River above the rapids at Sault Ste. Marie. (47) These works, including a 16-gate control structure, powerhouses and canals and locks, were built as a condition of an order of the International Joint Commission granting a permit to divert water around the rapids for power generation (to prevent lowering of Lake Superior). The same order also created an International Lake Superior Board of Control, consisting of an officer of the Corps of Engineers and an officer appointed by the Canadian government.

It is the function of the Board to determine the amount of water available for power generation and to maintain as nearly as possible the level of Lake Superior to its low datum of 600 feet. Since 1957, the level of Lake Superior from extreme low to extreme high has varied only about one foot.

In addition to precipitation and runoff, Lake Superior receives water by importation via the Long Lake-Ogoki hydroelectric projects located in Canada. This diversion averages nearly 5,000 cfs of water which formerly flowed north to Hudson's Bay. Because of the regulatory works at the "Soo" this diversion has not affected the level of Lake Superior.

There are over 100 streams in the three States which outlet to Lake Superior. Discharge information concerning the major streams is shown on Table 1. By far the largest stream tributary to Lake Superior is the interstate St. Louis River which enters the lake at Duluth-Superior. The lower St. Louis River has been extensively developed for production of hydroelectric power.

Most of the streams draining the north shore of Lake Superior are approximately 20 miles in length, characterized by a steep gradient and a high fluctuation in flow level. The one exception to this is the St. Louis River.

The Lake Superior drainage in the State of Wisconsin consists of a series of small streams flowing through the escarpment which exists around the south shore. Falls and rapids are characteristic along the escarpment line with some streams having hydro-power development. There are six hydroelectric power installations on the tributary streams.

There is a total of 78 streams in Michigan which outlet to the lake. The largest of these streams is the Ontonagon which has a drainage area of approximately 1,400 square miles.

There are approximately 2,000 lakes having areas of ten acres or more within the watershed. Most of the lakes occupy depressions in glacial deposits or are in ice block basins formed after the retreat of the glaciers. Approximately 600 of the lakes are in the north shore watershed area in Minnesota.

The ground water resources of the area bordering Lake Superior are quite variable. In many cases the glacial drift is too thin and discontinuous to provide adequate supplies of water. In portions of the basin, namely the St. Louis River watershed, there are extensive areas of unconsolidated sand and gravel which, in general, yield large quantities of water. In general, the quality of ground water is satisfactory for all uses.

TABLE 1
MAJOR UNITED STATES TRIBUTARIES TO LAKE SUPERIOR*

<u>Name of River</u>	<u>Total Drainage Area (Sq. MI.)</u>	<u>Gaged Drainage Area (Sq. MI.)</u>	<u>Mean Discharge (cfs)</u>	<u>Period of Record (Water Yrs.)</u>
Pigeon	610	600	483	1923-67
Brule	282	0	-	-
Baptism	146	140	159	1927-67
St. Louis	3,652	3,430	2,202	1908-67
Nemadji	446	0	-	-
Bois Brule	185	113	169	1942-67
Bad	1,016	611	605	1914-22 1948-67
Montreal	281	262	325	1938-67
Black	257	200	227	1954-67
Presque Isle	359	261	264	1945-63
Ontonagon	1,390	1,340	1,374	1942-66
Sturgeon	729	705	795	1942-66
Dead	166	0	-	-
Chocolay	161	0	-	-
Tahquamenon	820	790	849	1953-66
Waiska	147	0	-	-

*Counterclockwise from U.S. (Minnesota) - Canadian Border

Data Source: USGS Surface Water Records of Minnesota and Wisconsin, 1967
USGS Surface Water Records of Michigan, 1966



Whitewater rapids and cascading falls are characteristic of Lake Superior's tributary streams.



Scale: 0 50 100 miles

NET SURFACE CIRCULATION OF LAKE SUPERIOR

LEGEND:

—→ Synthesized current patterns

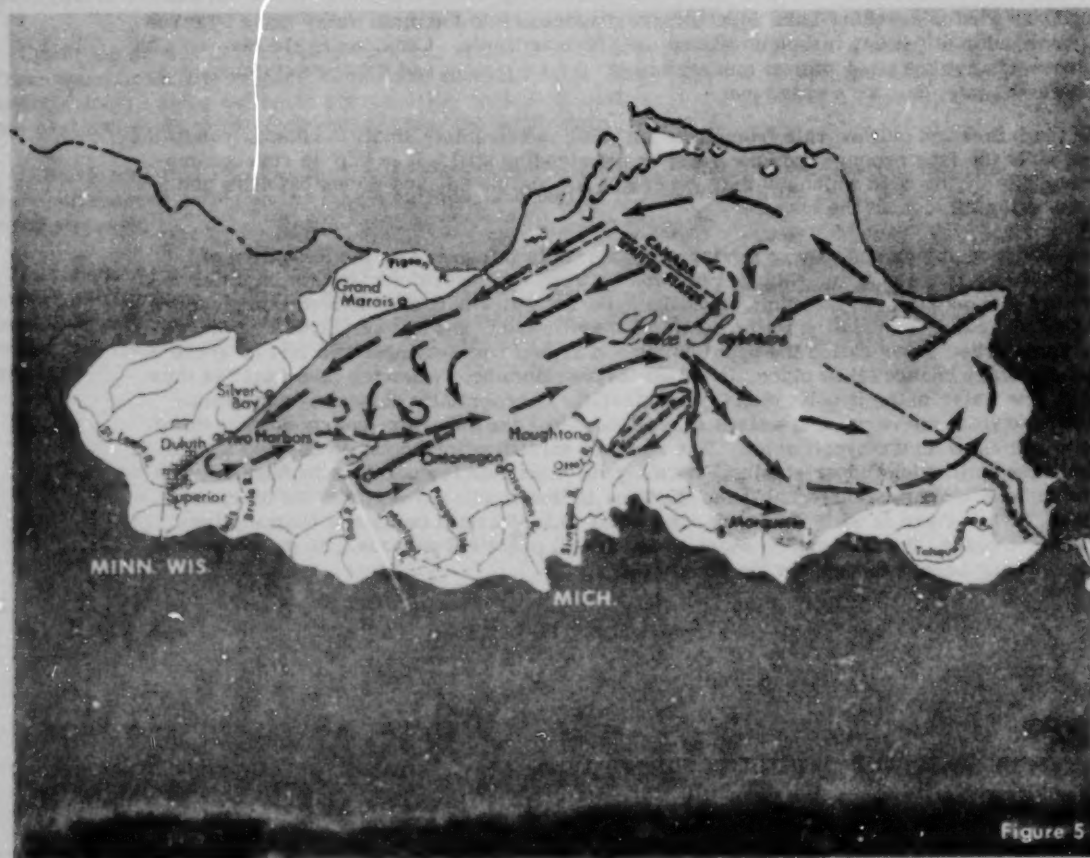


Figure 5



There is a pleasure in the pathless woods,
There is a rapture on the lonely shore.

Lord Byron "Childe Harold"

WATER USES

The waters of Lake Superior are used for municipal and industrial water supply; recreation, including swimming, boating, fishing and other water oriented sports; commercial fishing; propagation of fish and aquatic life; commercial navigation; and esthetic enjoyment.

The waters of Lake Superior are of excellent quality for municipal water supply. Twenty-four municipalities and communities withdraw water from the lake for domestic usage. These systems serve approximately 184,000 people which use 25 million gallons per day (mgd). Communities in Michigan use approximately 5.7 mgd; Wisconsin approximately 1.3 mgd; and Minnesota approximately 18.0 mgd. The largest domestic supply is for the city of Duluth, which uses approximately 16 mgd, more than 60 percent of the total. Eight other communities in the basin utilize surface sources other than Lake Superior, withdrawing about 1.8 mgd. The remaining communities in the basin rely on ground water for their supply.

A twenty-three mile long water line is being constructed from Duluth to Cloquet, Minnesota to convey Lake Superior water to Cloquet for domestic and industrial water supplies. The pipe line will also serve the city of Superior, Wisconsin. The ultimate design capacity of the pipe line is 40 mgd. The initial capacity of the system will be 25 mgd. The scheduled completion date for the project is March 31, 1969.

An estimated 563 mgd of Lake Superior water is withdrawn for industrial purposes. Of this total 518 mgd are used by Minnesota industries, 42 mgd by Michigan industries and 3 mgd by Wisconsin industries. The largest single water user is the Reserve Mining Company taconite beneficiation plant at Silver Bay, Minnesota, which accounts for more than 90 percent of the total Lake Superior water used by industry. The use of industrial water on the tributaries of Lake Superior total approximately 200 mgd of which approximately 70 percent is used by the iron mining industries on the eastern end of the Mesabi Range in Minnesota.

LAKE CURRENTS

Circulation studies of Lake Superior were begun in October 1966 by the FWPCA to determine the water circulation pattern of the lake, to establish the cause and effect relationships so as to be able to predict the movement of pollutants occurring in, and being discharged to the lake, and to develop a more accurate description and understanding of the physical, biological, and chemical phenomena of the lake.

To accomplish this, seven current-metering stations were emplaced in Lake Superior in October 1966. In May 1967 these meters were recovered and replaced and the current-metering network was expanded to a total of 17 stations. These stations were recovered in October 1967.

The current-meters were Richardson type, self-contained recording instruments, clock-activated periodically (every 30 minutes), recording directional and speed data for one minute on 16mm film then shutting off until the start of the next cycle. At each station current-meters were suspended at depths of 30, 50, 75 and 100 feet and every 100 feet thereafter. Temperature recorders were also installed at these depths.

The data from these stations were analyzed using accepted oceanographic techniques. What follows is a discussion of the findings.

Waterborne wastes reaching Lake Superior are dispersed into the main water mass by three means; molecular diffusion, turbulent mixing, and lake currents. Considering the lake as a whole, currents are the predominant mechanism for the movement and subsequent dispersion of these wastes into the lake's water mass.

While the inflow and outflow rate from Lake Superior is extremely small in comparison to the water mass of the lake proper, the lake water is not standing still. It is kept in constant motion principally by the wind which not only generates the visible surface waves but stirs and mixes the water throughout the lake.

Both water movements and rate of mixing are materially influenced by the formation of thermoclines, or zones of temperature transition between two layers of water which differ in temperature and density. In the summer, Lake Superior water becomes divided into an upper layer of warm readily circulating water, called the epilimnion, and a lower layer of cold, relatively undisturbed water called the hypolimnion. A region between these two layers where rapid temperature change takes place, is called the thermocline. When the lake water is thus stratified, the water in the hypolimnion (lower stratum) is essentially physically and chemically isolated from the remaining waters of the lake. In Lake Superior, nearly 95 percent of the lake's volume is in the hypolimnion. The summer stratification begins to develop in mid-June, with the epilimnion (upper stratum) reaching its maximum temperature in August. The thermocline is somewhat transient in Lake Superior in that it will move in and out of an area of the lake. When there is no thermocline, the water is isothermal (without a thermocline). In the winter months, the lake can be considered, for all practical purposes, to be isothermal and water mixing occurs throughout the lake.

Thermal bars, a phenomena resulting from a difference in temperature between adjacent waters along a vertical plane, occur in the spring and fall in shallow waters parallel to the shoreline. The fall thermal bar is not as extensive nor as well developed as is the one that occurs in the spring. A thermal bar inhibits mixing between the shallow waters along the shore and the deeper lake waters. Wastes discharged into the inshore side of the thermal bar tend to be held in the inshore area.

Because currents in the lake are motivated principally by the wind, and winds are variable, horizontal movement of the lake water exhibits an infinite variety and frequent changes in both direction and speed. A current change in less than six hours after a wind shift is common in mid-lake. The nearshore response may be even more rapid. However, certain recurring patterns have been identified, resulting principally from the fact that winds from one direction predominate.

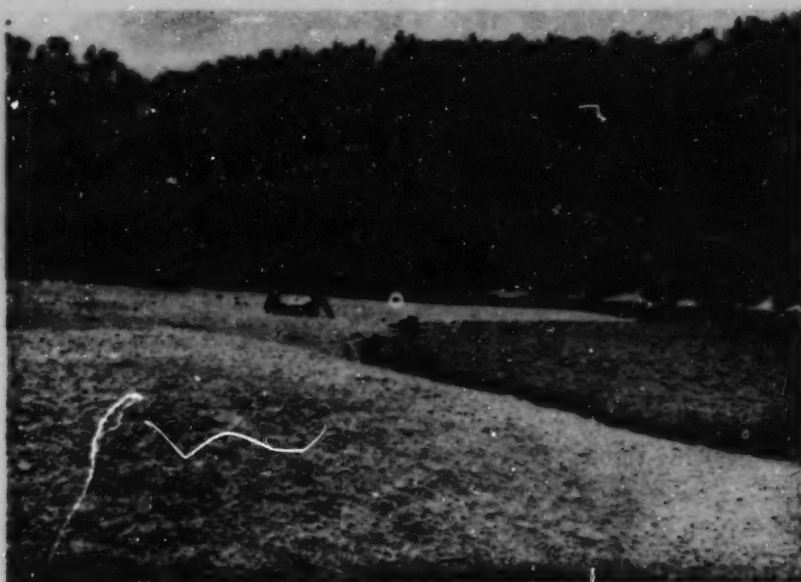
The net circulation of Lake Superior is counter clockwise, with the possibility of large cyclonic eddies occurring in the western arm, or Duluth embayment, between Isle Royale and the Keweenaw Peninsula, and in the eastern basin. See Figure 5.

Superimposed on the net circulation pattern of the lake are other factors that affect water movement. The net circulations, while on a long-term basis may be considered the circulation pattern of the lake, exist for only short periods of time. One week would be considered a long period of time for the total net circulation pattern to exist.

Upwelling occurs in the lake when winds cause horizontal surface movement of water away from the shore. The surface waters are replaced by colder, deeper waters. Upwelling frequently occurs along the north shore during periods of northwest and west wind. Winds from the east and south produce upwelling along the south shore.

Other forces that affect water movement are internal waves, caused by storms and/or pressure differences acting on the lake's surface, and inertia currents resulting from decaying wind stresses.

In summary, while there is a net circulation pattern in the lake, a great many forces are acting which have a modifying effect upon water movements. These water movements are such that any persistent pollutant entering directly into Lake Superior or discharged into the water that feeds the lake, mixes with and becomes an integral part of the lake water as a whole.



There is a pleasure in the pathless woods,
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Total electric power generation in the Lake Superior basin, including hydroelectric and steam generation, is estimated at about 850 megawatts. The largest hydro-power development in the basin is on the St. Louis River in Minnesota with a total installed capacity of 88,860 kilowatts. Steam power generation is estimated at approximately 650 megawatts, of which more than 60 percent is produced in Minnesota. A total of approximately 500 mgd of Lake Superior water is used for cooling purposes. Surface water other than Lake Superior used for cooling purposes totals approximately 130 mgd. There are at present no nuclear generating plants in the Lake Superior basin.

Records on commercial fish catches in Lake Superior have been kept since 1879. The catch averaged 7.8 million pounds from 1879 to 1908; 10.5 million pounds from 1913 to 1928; and 15.6 million pounds from 1929 to 1963. The catch reached a maximum of 22.1 million pounds in 1941 but since has declined to a 1967 level of 7.9 million pounds. The decline is related to biological and economical factors. In 1967 Lake Superior ranked third in commercial fish catches for the United States portion of the Great Lakes. Lake Michigan, 59.0 million pounds and Lake Erie 11.6 million pounds ranked first and second respectively.

There are relatively few fish species that constitute the bulk of the commercial catch in Lake Superior. Lake trout are undoubtedly the most popular and valuable fish. The maximum lake trout catch of 5.6 million pounds occurred in 1903. Between 1903 and 1955 the catch ranged between two and three million pounds, reaching 3.7 million pounds in 1944. The catch since 1955 has declined steadily, with the 1961 catch dropping to 323,000 pounds. From 1962 to the present lake trout fishing has been allowed under permit only. The chief cause of the decline of the lake trout was predation by the parasitic sea lamprey. Only drastic reduction of the sea lamprey population and intensive stocking by State and Federal agencies prevented total collapse of the lake trout fishery. A small amount of natural lake trout reproduction has now been found but the fishery at the present still depends upon stocking from hatchery raised fry. Indications are the population of lake trout in Lake Superior is increasing.

Drastic changes in the production of lake herring have occurred in the past twenty years. A maximum production of approximately 18 million pounds occurred in 1941 in United States waters, and declined to 10.8 million pounds in 1960. The abundance of herring has dropped significantly in the 1960's declining to 3.8 million pounds in 1967. White fish production, which typically fluctuates between 400,000 to 800,000 pounds, is currently about 500,000 pounds. A maximum catch of 1.3 million pounds was recorded in 1949. The smelt population, which at present produces a catch of 1.5 million pounds, is suspected as a causative factor in the decline of a number of native fish species. Chubs have been harvested to an increasing extent beginning in the late 1950's with production reaching 1.3 million pounds in 1959. The catch for 1967 was 1.9 million pounds. This fishery increased only out of economic necessity arising from the decline of lake trout.

The Lake Superior basin is an area of outstanding natural resources and great recreation potential. However, at the present only moderate demands are being placed on the basin's recreation resources. The relative inaccessibility of many recreation areas, because of their considerable distance from large population centers and a lack of better destination routes, in conjunction with a short tourist season are primary factors creating this situation. The current annual recreation demand is estimated at nearly 16 million recreation days. By the year 2000 this amount is expected to nearly double. Approximately 80 percent of the present demand can be attributed to vacation use.

In 1964 an estimated 1.4 million vacationists came to the Lake Superior basin for the primary purpose of outdoor recreation. The vacation sector comprises approximately 80 percent of the basin's total effective population. This approximation does include a few basin residents but by far the greater number are non-residents.

While the list of recreation activities available in the basin is quite endless, the vast majority of recreation activities in the basin are centered around or near water. These include boating, fishing and those activities significantly enhanced by the presence of water such as hiking, camping, sight-seeing and driving for pleasure.



Pleasure boating is rapidly increasing in the Lake Superior basin.

The United States Bureau of Outdoor Recreation report, "Water Oriented Outdoor Recreation - Lake Superior Basin" (44), presents a detailed discussion of recreation in the basin including information on existing facilities, the problems that are developing, and the action that must be taken to preserve this natural heritage.

Even though it is recognized that recreationists participate in all the other basic activities in addition to sight-seeing, it is the attraction of this latter activity which draws most recreationists to the basin. Probably Lake Superior's greatest asset is its scenic shoreline.

Water quality is a most important factor influencing the recreational uses which are made of the water, as it affects the quality of the outdoor recreation experience. Water oriented recreational activities may be divided into two categories -- one of which involves actual contact with the water. This category is further broken down into activities involving the whole body contact such as swimming and water skiing and those involving limited contact such as pleasure boating and fishing. The other category involves the esthetic enjoyment of viewing the body of water and its surroundings. This includes such activities as driving and hiking for pleasure along the shore of the body of the water. An important part of the recreational value of water is its esthetic aspect. Camping, picnicking, sight-seeing, while not directly water oriented activities, are considerably enhanced as an experience by esthetically pleasing water. Some pollution robs the water of its esthetic value for such activities.

The severity of a pollution problem can vary from place to place on a given body of water and in many instances from time to time depending on weather and other factors. In addition, people vary widely in their opinions as to the point at which water quality has deteriorated to the extent that it is no longer suited for a certain recreational activity.

Therefore, it can be seen that water quality per se has a demonstrable effect on recreational use. Many of the factors which contribute to the degradation of water quality can be measured readily; for example, rise in water temperature due to thermal pollution and amount of silt added to a stream as a result of land runoff. However, sociological factors which are very difficult to measure, play a key role in determining the extent to which quality will influence recreational use. These latter factors become very personal and differ with the individual depending upon his education and environmental background.



Numerous State and Federal lands in the Lake Superior basin offer recreational opportunities that can be enjoyed by all.

III. THE POLLUTION PROBLEM

Lakes may be classified according to their level of primary productivity. The productivity or "fertility" of a lake depends on nutrients received from regional drainage, on the depth, plus other interrelated factors which affect the metabolism of the lake. A eutrophic lake is at one end of the classification series and on the other end is an oligotrophic lake. While there are a number of characteristics associated with oligotrophic lakes, in short they are still "biologically young" and have changed little since the time of their formation.

Lake Superior is an excellent example of an oligotrophic lake having very clear, cold water and very few living organisms. The lake is an exceedingly young lake in terms of its biological aging processes. It is thousands of years behind the other Great Lakes considering only natural aging. The lake nearly resembles its pristine condition as created eons ago.

Lake Superior has been the least studied of all the Great Lakes. Most of the studies conducted have been in the western portion of the lake. There are very little data for the lake during the winter season and essentially nothing is known about bottom organisms, bottom character, and fish species in the deeper portions of the middle of the lake.

Lake Superior is a delicate lake and therefore great caution must be exercised when weighing the potential dangers to its ecology. Increases normally considered insignificant or acceptable in most lakes will dramatically alter this lake, because even such small changes will represent a large percentage of change. For example, an increase in 5 units in turbidity will result in a reduction of many feet in light penetration and significant loss of fish food organisms. The very cold temperatures keep production of phytoplankton at a very low level. The growth of algae in the lake can be loosely compared to algal growth that would occur in a beaker of water placed in a lighted refrigerator.

It is also true that a slight reduction in the food producing capacity of the lake is likely to evidence itself in lower fish production because food appears to be limiting in the lake. Shallow shore areas, one of the major fish food producing areas in the lake, are limited and therefore are extremely important to the survival of the fish species of the lake. These are the same areas first to be affected by man-made waste discharges. Because algae productivity is low, the depth to which light penetrates is important for producing sufficient plankton, periphyton and benthos in the shore areas.

The native fish species in Lake Superior such as lake trout have long egg incubation periods; some of them reaching two to three months. Conditions must be ideal during this critical period to enable the eggs to hatch. Because the eggs are deposited on the lake bottom, small quantities of silt or settleable solids are likely to smother the eggs as they are left unattended by the adult fish.

The addition of certain kinds of toxic materials into Lake Superior is of prime importance. The heavy metals (i. e., copper, iron, zinc, etc.) are highly toxic at low concentrations because the water is soft, the fish species found in the lake are sensitive to metals and because the metals are persistent and will remain in the lake for longer periods of time due to the lake's slow flushing rate. Many of the common metals found in the surface waters could seriously affect the reproductive potentials of the fish species in Lake Superior at concentrations in the range of 2 to 50 parts per billion.

The quality of Lake Superior water is so high compared to other lakes that the early signs of damage may go undetected or may be excused as being insignificant. Using standards of clean water normally considered appropriate in pollution control programs, Lake Superior could be degraded considerably and changed significantly before water uses would be damaged.

Pollution problems have occurred in the Lake Superior basin. Some of the existing problems, both in the lake and on the interstate tributaries are discussed in the following sections.

CHEMICAL POLLUTION

Pollution by dissolved chemicals covers a broad range of substances including heavy metals such as copper, iron and zinc, phenolic compounds, oil, nitrogenous materials, phosphorus, chlorides, and colored waters. Two general types of effects are produced by such chemicals: (1) local and immediate effects in the vicinity of the source, and (2) a progressive buildup in the concentrations of certain persistent chemicals in the lake as a whole. Concerning the latter effect, great caution must be exercised in order to avoid long-term damage in Lake Superior as the self-purging rate has been estimated to be well in excess of 500 years (45). In addition, eddy currents that may occur in the western end of the lake tend to limit the intermixing of these waters with the rest of the lake.

Lake Superior and Lake Michigan are the headwaters of the Great Lakes as their outflow passes through Lakes Huron, Erie and Ontario. Constituents dissolved in Lake Superior waters such as nutrients which tend to accumulate in a lake could therefore add to the accumulated levels in these downstream lakes. While the effects of these dissolved constituents may not be felt in Lake Superior due to other limiting factors, conditions may be suitable in the downstream lakes to result in a degraded water quality.

The heavy metals, as a group, are especially important in Lake Superior for several reasons. Because there is a low mineral concentration in the lake, metals are more toxic than they would be in average waters in the United States. In addition, several important species of fish, especially lake trout, whitefish, and lake herring, are unusually sensitive to such metals as copper, zinc and chromium. Natural agents are lacking in the lake to bind such metals and render them inactive.



An industrial waste discharge to a tributary stream in Wisconsin causes a discoloration of Lake Superior waters.

Heavy metals are reaching Lake Superior through natural erosion of the mineral laden rock in the drainage basin and as a result of mining activities. Amplification of aspects related to mining activities is found in another section of this report.

Very important chemical constituents in a lake are the levels of nitrogen and phosphorus. Aquatic vegetation including algae are capable, through photosynthesis, of utilizing inorganic elements in support of growth -- including nitrogen and phosphorus. These nutrients have been given the most attention because following carbon, they are required in the greatest amounts for the production of green plants. Bodies of water receive these nutrients from many sources such as natural runoff from agricultural and urban land, ground water, precipitation and sewage and industrial waste effluents.

Information available shows that in Lake Superior, overgrowth of algae is not a problem. The low temperature of the water is very likely a limiting factor in the lake's productivity. The harbor areas and inshore lake water near the harbors are most susceptible to nuisance aquatic vegetation growths because they are more easily affected by man's activities and because other conditions, such as higher water temperatures and phosphorus concentrations necessary for nuisance conditions, more frequently occur.

The three States in the basin have included statements on phosphorus removal in their interstate water quality standards. In addition, the Michigan Water Resources Commission adopted a resolution in October 1967, which calls for the removal by June 1, 1977 of phosphorus compounds from wastes discharged to the waters of the State. Minnesota has adopted statewide effluent standards which require the removal phosphorus from waste discharges to certain lakes and reservoirs. The cities of Duluth, Two Harbors, and Grand Marais have been required to install phosphorus removal facilities by 1971; Silver Bay by 1972.

OXYGEN DEPLETION

Dissolved oxygen (oxygen held in solution in water) provides the basic respiratory supply for most living organisms, including not only fish but also the bacteria which consume organic matter. Therefore, dissolved oxygen is a most important ingredient necessary for a healthy, balanced aquatic life environment. Decomposable organic matter can cause an excessive reduction of the dissolved oxygen concentrations in the water because oxygen is consumed by the respiration processes of some living organisms. The oxygen is replenished by absorption from the atmosphere and through the photosynthetic processes of aquatic plants provided a well balanced environment exists. Organic pollution alters the environmental balance. The bacteria in the water or introduced with the waste, utilize the organic matter as food, multiply rapidly and reduce the dissolved oxygen. The resulting oxygen deficiency may be great enough to inhibit or destroy fish and other desirable organisms, and result in taste and odor problems. Excessive depletion of the dissolved oxygen results in the generation of many nuisance conditions.

At the present time the main body of Lake Superior has not shown any signs of oxygen deficiency. (13, 22, 31, 32, 35) This coincides with the characteristic of an oligotrophic lake in that there is ample oxygen at all water levels within the lake. In this case, the oxygen levels are at or near the saturation point at all depths.

Oxygen depletion is occurring in some of the tributaries draining into Lake Superior. In the Minnesota drainage, reaches of the lower St. Louis River from Cloquet to the Duluth - Superior harbor have on numerous occasions been excessively depleted of oxygen. (38, 55) Inadequately treated sewage effluent and inadequately treated industrial wastes discharged into this reach have been the source of the problem. The condition is aggravated by the operation of the hydroelectric plants on the river which cause wide fluctuations in river flow.



Industrial waste discharges to the lower St. Louis River have caused serious pollution problems.

Sources of waste in the Duluth - Superior harbor have also created localized areas of substantial oxygen depletion. Sources of pollution include inadequately treated municipal wastes plus inadequately treated industrial wastes from various points.

The interstate Montreal River downstream from Hurley, Wisconsin and Ironwood, Michigan has experienced oxygen depletion problems. (12) The proportion of the oxygen depletion caused by the waste discharges from each of these two cities has not been determined.

Under the provisions of interstate water quality standards, the State regulatory agencies have initiated actions to eliminate the oxygen depletion problems occurring on the tributary streams.

BACTERIAL POLLUTION

The presence of coliform organisms in water is considered an indicator of degraded water quality and a possible indicator of a health hazard. Coliform organisms are significant because they occur in the fecal matter of all warm-blooded animals, including man. Consequently, the presence of these bacteria in a body of water is considered evidence of fecal contamination. Since such contamination is one avenue of transmission of certain waterborne disease, the presence of coliforms is also an indication of a health hazard from accompanying pathogenic bacteria and viruses.

The largest coliform concentrations in water are usually produced by human contamination, but elevated counts will also occur after rainfalls due to land runoff and/or storm and combined sewer overflows. Pathogenic bacteria from human sources can be adequately controlled by proper treatment and disinfection of waste discharges.

The bacterial quality of the main body of Lake Superior is excellent. The problems of bacterial contamination that have occurred were found along certain tributaries and some harbor or inshore areas around the lake. Instances of impairment of water use in the basin by bacterial pollution have been documented by the Bureau of Outdoor Recreation. (44) Some of the areas that have experienced bacterial pollution are portions of the St. Louis River and Duluth Harbor area in Minnesota; and Superior Harbor area, Ashland inshore area and reaches of the Montreal River in Wisconsin.

Some cities in the basin are served by combined sewer systems so that quantities of a mixture of storm water and sewage are discharged without treatment during and after every heavy rain. This has resulted in bacterial pollution of some reaches of rivers in the basin. Bacterial pollution in most cases is amenable to correction. This is the case wherever the waste can be put through a treatment plant followed by disinfection.

The State regulatory agencies have taken actions to eliminate existing bacterial pollution problems and to prevent future undesirable conditions. The States of Michigan and Wisconsin require year around disinfection of waste treatment plant effluent. Minnesota requires year around disinfection at all waste treatment plants in proximity to water supply intakes and seasonal disinfection of effluents discharged to waters used for recreation. In addition, all three States have required separation of combined sewers or other remedial action to prevent pollution from this source.

MINING ACTIVITIES

There are 151 active mineral operations within the Lake Superior basin. Table 2 shows the distribution by State and mineral commodity of these operations. Not all of these operations are "wet" industries, i. e., utilize quantities of water in their processes. The waste disposal practices followed by the "wet" operations are shown in Appendix A.

There have been water quality problems associated with mining operations in the basin. Wastewater originates from open pit iron ore mining as a result of the entrance of rainwater and seepage into the mines. The water must be pumped out to maintain a dry area for mining operations. The quantity of water may range from almost nothing to several thousand gallons per minute. This water may be highly colored and very turbid or may be crystal clear, depending upon the type of ore body and manner of collection.

Ordinarily pit water which is pumped from the bottom of an open iron ore pit is extremely turbid, has a bright red color, and may have a very high suspended solids content. The term "red-water" is frequently applied to this and similar wastes for obvious reasons. The occurrence of red-water resulting from natural drainage is also quite common in the streams near ore dumps.

The discharge of water or drainage containing large quantities of suspended material into surface waters may create unfavorable conditions for fish and wildlife. It also may affect the use of recreational areas, and stream shore property. If large amounts of suspended materials settle out in shallow areas, fish spawning beds may be covered and the penetration of light so reduced as to have an adverse effect on the growth of aquatic plant and animal life. The red color of the material in the water from mining areas emphasizes the presence of suspended material which tags the waters in the area.

Although periodic problems do arise as a result of red-water, control measures by the State regulatory agencies have proved to be effective in combating this problem.

TABLE 2

97

ACTIVE MINERAL OPERATIONS IN LAKE SUPERIOR BASIN

<u>MINERAL COMMODITY</u>	<u>MICHIGAN</u>	<u>MINNESOTA</u>	<u>WISCONSIN</u>
Iron Ore	9	27	
Copper	7		
Sand & Gravel	32	50	10
Iron & Steel		1	
Cement		1	
Clay		1	
Granite			2
Lime		1	1
Peat		4	
Stone		1	
Total	52	86	13



Reserve Mining Company's E.W. Davis taconite beneficiation plant at Silver Bay. Light areas are tailings being carried by a stream of water a few inches deep over the solid delta beach to the lake.

Active underground mines must continually be drained and previously abandoned shafts that are being reopened to development must be drained to allow full operation. This water is characteristically quite high in total dissolved solids such as chlorides and sulphates. Depending upon the nature of the underground strata, heavy metals such as copper, iron and zinc will be leached from the soil and be contained in this discharge water. As stated previously in this report, the discharge of heavy metals to the waters of Lake Superior is of concern due to the extreme sensitivity of aquatic life in the lake to these metals and due to the long-term buildup of these metals in the lake. A quantification of the past practices of draining mines is not available. Care should be exercised in the future to prevent the adverse effects on aquatic life in the receiving streams and also to Lake Superior from such drainage practices.

With the development of the taconite beneficiation process, vast new areas were opened up to the mining of taconite ore. As can be seen by Table 2, there are 36 mineral operations related to taconite processing in the basin including 15 concentrator plants. As shown in Appendix A, 14 of these utilize a closed system whereby their wastewater is allowed to settle in a lagoon and the waters recirculated for use. One of these concentrator plants, Reserve Mining Company, E. W. Davis Works, discharges its wastes directly to Lake Superior. The operations of this plant are discussed below.

Reserve Mining Company, E.W. Davis Works

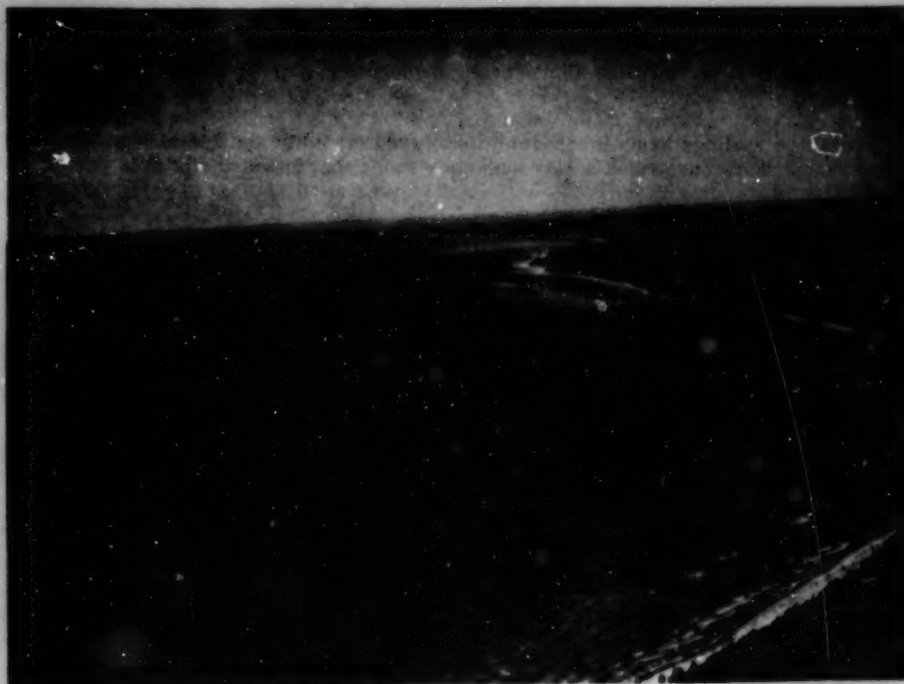
In response to a request from the U.S. Army Corps of Engineers for comments on revalidation of the Corps' permit to Reserve Mining Company, several agencies of the U.S. Department of the Interior and other units of government reported continuing concern over the deposition of taconite tailings into Lake Superior. In response to these concerns an Interior study group was formed to investigate the effects of the taconite tailings on Lake Superior. Participating Department of the Interior agencies in the Taconite Study Group were Regional Coordinator, Office of the Secretary, Chairman; Bureau of Sport Fisheries and Wildlife; Bureau of Commercial Fisheries; Bureau of Mines; Geological Survey; and FWPCA. The U.S. Army Corps of Engineers, Minnesota Department of Conservation, Minnesota Pollution Control Agency, and Wisconsin Department of Natural Resources provided information to the study group and acted as observers in the group's activities.

Based on data gathered by the individual agencies comprising the Taconite Study Group (49, 50, 51, 52, 53) and other State reports (54), the following conclusions were reached:

1. Approximately 45 percent of the tailings waste discharged between 1956 and 1967 were deposited on the delta off shore from the plant. The remaining 55 percent, or approximately 95 million tons, traveled down the face of the delta into the lake. Tailings are deposited on the lake bottom at least 10 miles off shore and 15 miles southwest of the plant.
2. Approximately 60,000 long tons of taconite waste are discharged daily from the plant. Fifty-four hundred long tons per day of the waste solids discharged to Lake Superior are less than 4 microns (1 micron equals 1/25,400th of an inch) in diameter. Particles of this diameter are capable of remaining suspended in water for a considerable time after discharge.
3. Current measurements in the vicinity of Silver Bay show that the prevailing current is to the southwest and of sufficient velocity to transport particles of 4 microns or less more than nine miles per day.
4. As the tailings meet Lake Superior water, "billowy gray clouds" of waste were visible leaving the density current, both at and under the water surface near the shore line. Extending off shore as far as 300 feet, these clouds were observed and photographed at a depth of 35 feet. It appeared that "green water" was formed as gray tailings clouds diffused (became less concentrated) and more daylight penetrated among the particles.

5. The occurrence of tailings was evident in "green water" masses. In one instance the "green water" containing tailings was visibly present 18 miles southwest from the plant. "Green water" was observed along the Wisconsin shore line and did not contain tailings.
6. "Green water" containing tailings has a measurably increased turbidity and contains at least two to three times more suspended solids than does water that appears clear to the eye.
7. The State of Minnesota report (54) reported a reduction in the abundance of fish food organisms associated with the deposition of taconite tailings on the bottom of Lake Superior. It was estimated the reduction in fish food organisms could be expected to result in a reduction of the total annual fish catch (commercial and estimated sport fishing) of 5 percent or less for the area having tailings on the bottom.
8. The study area selected (nine miles by five miles) for sampling was too small to define the full extent of the area adversely affected. Analysis of data by the Study Group indicates that the area affected extended beyond the furthest sampling point.
9. High concentrations (10 percent and 25 percent) of taconite wastes caused mortalities among sac fry of rainbow trout in 4-day exposure. The wastes were not acutely toxic to fingerling sized coho salmon, rainbow trout, white suckers, black bullheads, blue gills, and yellow perch in 96-hour, static bioassays.
10. Chemical analysis projected to the probable daily discharge shows the following discharge, measured in pounds of certain parameters: copper, 4,100; nickel, 2,500; zinc, 2,500; lead, 6,100; chromium, 6,200; phosphorus, 51,500; and manganese, 629,000. Other elements in the discharge include silica, arsenic, and substantial quantities of iron. The chemical state of these metals was not assessed and it would be presumptuous to say at this time what portion of the elements enter into solution.
11. A distinguishing characteristic of tailings discharged by the Reserve Mining Company is the presence of large quantities of the amphibole cummingtonite.

Data gathered by the FWPCA since April 1, 1969 has shown the presence of taconite tailings, (utilizing cummingtonite as a tracer) in the municipal water systems of Beaver Bay, Two Harbors, and Duluth, Minnesota. There has not been sufficient time to determine what effects, if any, the presence of the tailings has on the quality of the water supply or the users thereof.



A large portion of the south shore of Lake Superior is discolored by the sediment contained in discharges from streams draining the red clay area of northwestern Wisconsin.

SOIL EROSION

Tributary streams to Lake Superior discharge many tons of sediment annually to the lake. The sediment is derived from the natural processes of weathering and erosion of the rock and soil and by the activities of man in the basin, and is transported to the lake by the surface streams. The sediment yield is low when compared to the yields in other areas of the country. The estimated average annual yield of north shore streams tributary to Lake Superior is 10 tons per square mile. The low yield is due to the geology, soil types, vegetation and land uses in the basin.

An exception to the generally low sediment yields of Lake Superior tributaries are the streams along the south shore of the lake in the northwestern red clay area of Wisconsin. This area, containing 880,000 acres of land in Ashland, Bayfield, Douglas and Iron Counties is the most severely eroded and high sediment producing area in the basin. Limited data on the Bad River near Odanah indicates a long term average sediment yield of 278 tons per square mile.

Damage to valuable trout and recreational streams by sediment resulting from erosion of the red clay area has occurred. A large portion of the south shore of Lake Superior is discolored by the sediment contained in the discharges from these streams. This adversely affects the aquatic life in the lake by reducing the depth of light penetration and in settling on the lake bottom.

These problems have been recognized by interested Federal, State, and local agencies and are currently under investigation. The Red Clay Interagency Committee, comprised of Federal, State, and local representatives, issued a report in 1967 which identified the sources and causes of erosion and sedimentation and proposed an action plan for corrective measures. (38)

WASTES FROM WATERCRAFT

Commercial, recreational, and Federal vessels ply the waters of Lake Superior and are contributors of both untreated and inadequately treated wastes in the open lake and in the harbor areas. A study conducted by the Minnesota Water Pollution Control Commission (predecessor of the Minnesota Pollution Control Agency) in 1965 of the Port of Duluth concluded that raw and partially treated sewage and significant quantities of solid refuse and grease are discharged into Duluth harbor from both foreign and domestic vessels. They also concluded that facilities for collection and disposal of garbage, dunnage and similar refuse from foreign vessels exists at the port but are too small to serve all the shipping entering the port. As a result, domestic vessels and possibly a few foreign vessels dump this accumulated material overboard while out on Lake Superior and the other Great Lakes. The report recommended a vigorous program to control the disposal of all types of wastes from watercraft in the port. The report also recommended that the facilities for collecting the wastes be expanded and collection and disposal of solid refuse from all vessels both domestic and foreign be required.

Certain aspects of water pollution from watercraft have been documented in the report "Wastes from Watercraft" (48). This report principally considered pollution caused by the discharge of sewage, bilge and ballast waters, compartment washings, and litter. The report points out that the problem of pollution from watercraft is both widespread and varied; widespread because vessels and boats frequent all navigable water areas of the Nation and may trigger local pollution at any point along their path; varied because of the assortment of materials which may be spilled or discharged from vessels. A proposed program for the control of pollution from vessels set forth in the report covers four major waste categories: (1) sewage; (2) bilge and ballast waters; (3) litter and related solids; and (4) oil.

Item 10 of the Summary of Findings contained in the "Wastes from Watercraft" report states: "Federal laws and regulations prohibiting the dumping of litter, sewage, and wastewaters in specific locations are intended primarily to prevent impairment of navigation and the spread of communicable disease, animal diseases and plant pests. They are not now wholly effective in preventing water pollution." Bills have been introduced into the 91st Congress to control wastes from watercraft.

The States of Minnesota, Wisconsin and Michigan have laws dealing with the vessel pollution problem. Minnesota's law is applicable to pleasure craft registered in the State and permits the use of marine toilets equipped with a suitable treatment device approved by the Minnesota Pollution Control Agency. Registration is contingent upon certification that watercraft with marine toilets are equipped with an acceptable device. Types of devices accepted include macerator/chlorinators, holding tanks and incinerators. The State prohibits the discharge of other wastes and the abandonment of containers holding sewage or other wastes which may create a nuisance, health hazard, or water pollution. All waters of the State are included in the law.

The Wisconsin law applies to the inland waters of the State and, therefore, by definition does not apply to Lake Superior. On applicable waters the law requires the use of a holding tank on any boat which is equipped with a toilet that is not sealed. Chemical type toilets and incinerator type toilets may also be used provided the material cannot be disposed of into the water and that the toilet is of sufficient capacity to handle the passenger load. Wisconsin has prepared a similar bill for introduction into the current session of the Legislature that would apply to all waters within the jurisdiction of the State, which would include Lake Superior.

Michigan laws are specific in prohibiting garbage, oil, and refuse dumping from watercraft 25 feet or more in length. Also, the disposal of such wastes from smaller watercraft and the disposal of wastes from marine toilets could be prosecuted under the State's general health laws. The Michigan Water Resources Commission in January 1968 adopted a rule to control pollution from marine toilets on watercraft. The rule does not allow the macerator/chlorinator and does authorize the use of holding tanks or incinerators. The rule becomes effective January 1, 1970.

OIL POLLUTION

People throughout the world became aware of the destructive characteristics of oil spilled in the water environment, and the inadequacy of current measures for dealing with a major spill when the Torrey Canyon ran aground and broke up off the coast of England in March 1967. On May 26, 1967 the President of the United States directed the Secretaries of the Interior and Transportation to undertake a joint study to determine how the resources of the Nation could best be mobilized to counteract the pollutional effects of spills of oil and other hazardous materials in our waterways. One of the major needs disclosed by the study was for the development of a contingency plan to deal with emergencies involving Federal, State, and local agencies with due regard for each agency's statutory responsibility and capability. On June 7, 1968 the President directed the Secretaries of the Interior, Defense, and Transportation and the Director of the Office of Science and Technology to assume special responsibilities in strengthening our preparedness to act in the event of a major oil spill. The Secretary of the Interior was directed to assume primary responsibility for completing by July 31, 1968, a draft of a national multi-agency contingency plan for responding to major pollutional spills. The National Plan was approved by the President on November 13, 1968. The National Plan provides guidelines for the establishment of regional contingency plans. Regional Offices of the Federal Water Pollution Control Administration have developed framework regional contingency plans and are now expanding these plans in accordance with provisions of the National Plan.

Although oil pollution is presently not a significant problem in Lake Superior, steps have been taken to insure that a coordinated response of effort among Federal, State, and local agencies will occur in the event of a major spill. A Contingency Plan for Lake Superior has been developed in accordance with provisions of the National Plan by the Great Lakes Region of the FWPCA. The purpose of this Plan is to present guidelines to minimize the pollutional effects of a major spill of oil, or other hazardous materials in Lake Superior. The objectives of this plan are to develop effective systems for discovering and reporting the existence of a pollution incident, promptly instituting measures to restrict the further spread of the pollutant, application of techniques to clean up and dispose of the collected pollutants, and institution of action to recover cleanup costs and effect enforcement of existing statutes.

Major legal capabilities available to the United States to control oil pollution include the Federal Water Pollution Control Act as amended, the Oil Pollution Act of 1924 as amended, and the River and Harbor Act of 1890.

DISPOSAL OF DREDGED MATERIAL

Responsibility for the improvement and maintenance of the waterways of the United States in the interest of navigation has been delegated by acts of Congress to the U.S. Army Corps of Engineers. In carrying out this responsibility, the Corps dredges approximately 10 million cubic yards annually from Great Lakes harbors and in calendar year 1968 dredged about one million cubic yards from harbors on Lake Superior. Two-thirds of this total represented deepening of a portion of Duluth - Superior harbor. The normal annual maintenance dredging program in Lake Superior is around 300,000 cubic yards. This is conducted in some of the commercial harbors shown in Figure 4, and in small boat harbors maintained by the U.S. Army Corps of Engineers.

The Corps has followed the practice of disposing of most dredged material in authorized dumping grounds in the open waters of the Great Lakes. Dredging of areas outside the authorized navigation channels, in the vicinity of the docks, loading facilities, marinas, etc., is accomplished by private interests under permit from the Corps. The dredged material ranges from clean lake sand to river sediments which may be seriously polluted by industrial and municipal wastes. The dredgings may contain oil and grease, dissolved solids, nutrients and toxic materials.

Attention has been directed to the problem of the disposal of polluted dredged materials by the Great Lakes Region, FWPCA. The FWPCA is concerned about the long-term cumulative effect on incremental additions of these pollutants to the Great Lakes.

During the past two years the Corps of Engineers and Federal Water Pollution Control Administration have been carrying out a joint study of the water quality problems associated with dredging. A report of findings is now available for perusal at the Corps District Offices and various other locations. In the meanwhile, the Corps has provided alternate disposal of materials dredged from several of the most polluted harbors on the Great Lakes. No harbors in the Lake Superior are included in this pilot program.

Results of sediment analysis by the FWPCA in Lake Superior harbors indicate the presence of polluted materials in certain areas of Duluth - Superior, and Ashland harbors. The analysis showed the sediment contained unacceptable levels of oil and grease, phosphorus and chemical oxygen demand. The FWPCA will continue to assist the Corps of Engineers by classifying harbor sediments as to their suitability for open lake disposal. The Corps should continue their program of developing alternate disposal areas for polluted sediments.

PESTICIDES

In general, the problems associated with pesticides are problems involving biological magnification of the pesticides in food chains or human food. Furthermore, there is not enough information at this time to understand or even estimate the importance of a given concentration of an insecticide such as DDT in the water or the bottom sediments. Based on these reasons, the concentration of insecticides in fish tissues is one of the best ways of monitoring the contamination of pesticides in a lake.

The word insecticide will be used henceforth in this report because no information is available to suggest that any significant amount of pesticides, other than insecticides has been detected in Lake Superior.

Information necessary to determine the kinds and quantities of insecticides used in the Lake Superior basin was not available. Some data on the concentration in fish were found. Concentrations of insecticides are lower in the fishes of Lake Superior than in the fishes of any other of the Great Lakes according to data furnished by the Bureau of Commercial Fisheries. Compared to similar species from Lake Michigan these fishes have from four to seven times less DDT and two to seven times less dieldrin. The absence of a Dutch Elm disease problem, very little industry, and little farming, probably account for the low values reported. The persistent insecticides, such as the chlorinated hydrocarbons must be kept from entering Lake Superior. If they do accumulate there, damage will be apparent for a long period of time due to the slow flow-through time of the lake. Since the harvested organisms, fish, comprise a larger percentage of the lake's biomass than in the other Great Lakes, less insecticide need be added before unacceptable amounts will occur in the important fishes. This is especially important since the most important species, lake trout, is a long-lived, predatory species and therefore is an efficient accumulator of insecticides. The low organic matter content of the water and sediment will also favor accumulation of insecticides in fishes.

Studies made by the Bureau of Commercial Fisheries indicate that dieldrin presently poses no problem in Lake Superior. Dieldrin levels are little above usual detection limits. One important reason may be that little or no corn is grown in the basin and so the commonly used insecticide for corn, aldrin (that converts to dieldrin) is not extensively used.

DDT (including DDT, DDD and DDE) is also much lower in Lake Superior than in the other Great Lakes but in several species, chubs, lake herring, and larger lake trout, the concentrations are approaching 1.0 microgram per gram, or above, of wet weight of fish.

As part of the Lake Michigan enforcement conference, a Technical Committee on Pesticides was established to evaluate the pesticide problem in Lake Michigan and to recommend to the conferees a program of monitoring and control. The Committee determined that controls should be instituted to insure that the concentration of various insecticides did not increase above existing levels in Lake Superior. There are no indications of problems in Lake Superior fish resulting from these levels. The recommended levels by that Committee therefore were that the concentration of DDT in fish not exceed 1.0 microgram per gram; DDD not exceed 0.5 microgram per gram; dieldrin not exceed 0.1 microgram per gram and all other chlorinated hydrocarbon insecticides, singly or combined, should not exceed 0.1 microgram per gram. Limits apply to both muscle and whole body and are expressed on the basis of wet weight of tissue (56).

The Food and Drug Administration officially informed that same Committee that concentrations of 0.3 parts per million of several insecticides, including dieldrin, in the edible portion of a fish would be considered sufficient to warrant legal actions.

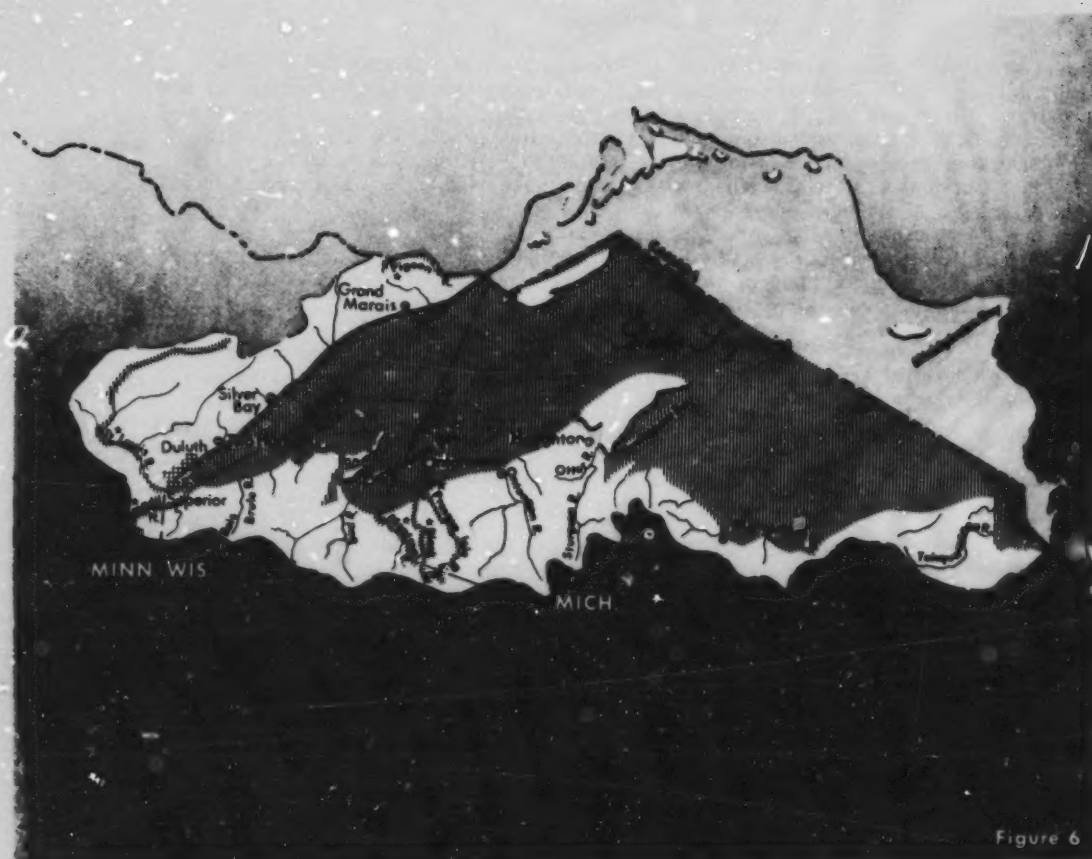
Indications are that uses of pesticides in the Lake Superior basin are at relatively low levels. Even with a low usage, insecticides are being concentrated in fish and underline the importance of caution and surveillance to avoid a future problem.



MAJOR INTERSTATE WATERS

LEGEND:

— Interstate waters



IV. POLLUTION CONTROL ACTIONS AND PROPOSALS

The necessary pollution control actions needed to prevent, control, and abate water pollution depend upon close cooperation with Federal, State, and local units of government. By working together and applying their respective capabilities the needed pollution control actions come into fruition. While the Federal role in water pollution control has become a very significant one, the basic Federal law recognizes the primary right and responsibility of the State agencies for the necessary pollution control actions in any State. Some of the actions taken by the State to abate pollution have been discussed in previous sections of this report. This section presents the Federal Water Pollution Control Administration program plus additional aspects of the State programs.

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION ACTIVITIES

The responsibilities of the Federal Water Pollution Control Administration were set forth by the Congress in the Federal Water Pollution Control Act passed in 1956 and subsequently amended in 1961, 1965 and 1966. The FWPCA, through the Great Lakes Regional Office, is pursuing a vigorous water pollution control program in the Great Lakes basin through close cooperation with the States and local agencies. The following is a brief description of some of the activities being taken in carrying out the agency's responsibilities. Particular reference is made to those activities relevant to Lake Superior and its drainage basin.

Water Quality Standards

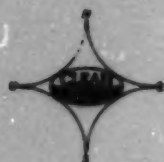
The Federal Water Pollution Control Act as amended by the Water Quality Act of 1965 authorizes the State and the Federal Governments to establish water quality standards for interstate waters. The water quality standards submitted by the States are subject to review by the Department of the Interior and if found consistent with the intent of the Act, are approved also as Federal standards by the Secretary of the Interior. Water quality standards include water use classifications, criteria necessary to support these uses and a plan for implementation and enforcement.

As part of the adoption procedure, public hearings are held to elicit citizens' views on proposed standards and to ascertain popular wishes as to the use of specific areas of lakes and streams. This action precedes formal State adoption of the standards.

Water quality standards have been adopted by the Lake Superior basin States under provisions of the Water Quality Act of 1965 and have been approved by the Secretary of the Interior. Michigan's temperature criteria as well as portions of Minnesota's standards have been excepted from approval. Figure 6 shows the major interstate waters of the Lake Superior basin, and Appendix B lists the criteria adopted by the States of Michigan, Minnesota and Wisconsin for the open waters of Lake Superior. A copy of the complete set of each State's standards is available from the appropriate State agency.

In addition to interstate standards, Michigan, Minnesota and Wisconsin have also adopted statewide intrastate water quality standards.

Lake Superior and many of the tributary waters have long been noted for excellent water quality and the resultant beneficial uses. Commitments to the preservation of existing high quality waters will play an important role in the preservation of the waters in the Lake Superior basin. The Lake Superior states have adopted policy statements establishing their intent to protect the present high quality of the interstate waters.



0 50 100 miles

CONSTRUCTION GRANT PROJECTS

LEGEND:

- Completed Projects

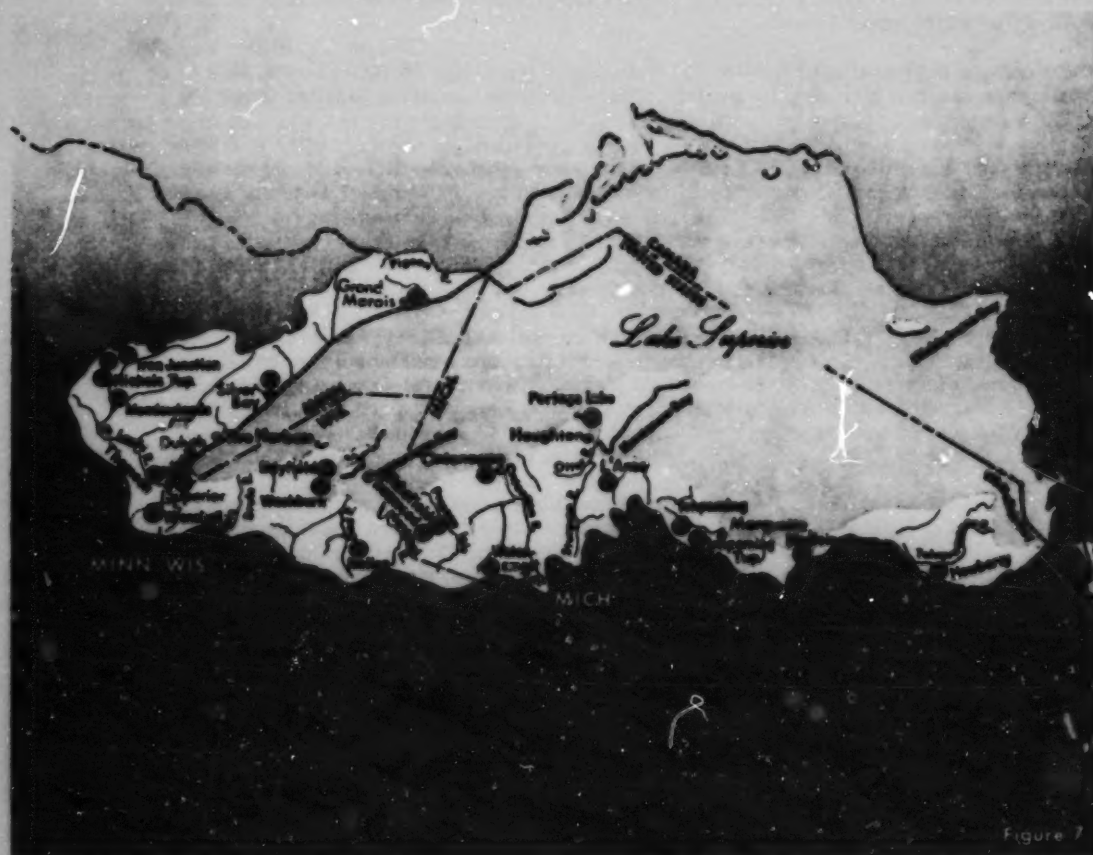


Figure 7

Great Lakes - Illinois River Basins Project

The Great Lakes - Illinois River Basins (GLIRB) Project was established in 1960 as a special task force in what is now the Federal Water Pollution Control Administration. With headquarters in Chicago, the project was charged with developing comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof in the Great Lakes, the Illinois River, and their tributaries.

The major objectives of the comprehensive program developed by the GLIRB Project in cooperation with other Federal agencies, with State water pollution control agencies and interstate agencies, and with the municipalities and industries involved were:

- Identification of the causes of water pollution and the effects of such pollution on the quality of water resources and on beneficial uses.
- The development of agreements on the desired beneficial uses and the water quality required to accommodate those uses.
- The development of water quality control measures to achieve the desired objectives, including the establishment of a timetable for their accomplishment.
- Provision of the mechanism for carrying out program objectives, including continuing surveillance for the purpose of updating the programs to accommodate changing technology and changing water quality needs.

Through reorganization of the FWPCA, the fulfilling of the major objectives of GLIRB ceased being the mission of a specific project. The objectives are being fulfilled under the total FWPCA program.

The established timetable of the GLIRB Project was such that only limited emphasis was placed upon the Lake Superior basin prior to the reorganization. The major accomplishment of the project with respect to the Lake Superior basin was the lake current study which is described in another section.

Construction Grants

With the enactment of the Federal Water Pollution Control Act of 1956, the Federal Government established a Federal sewage treatment works construction grants program to help finance the building of municipal sewage treatment plants. The Federal Government recognized that wastes discharged from municipal sewers are one of the major causes of water pollution. The growth of population and industry, coupled with the backlog of needed treatment works, resulted in a situation that called for increased treatment plant construction at the local level.

Since the 1956 Act, a total of 26 Federal grants have been made to communities in the Lake Superior basin to help build required sewage treatment facilities. Figure 7 locates these grants. Grant funds involved in these projects have totaled over \$2.9 million in support of total project expenditures in excess of \$8.8 million. All the Federally-assisted grant projects have been completed and placed in operation.

The Construction Grants Section of the Federal Act has been amended three times since its initial 1956 passage. The trend of financial assistance has been upward with each amendment. Today's legislation enables municipalities to qualify for consideration for a basic Federal grant of 30 percent of the eligible cost of a project. A grant of 40 percent can be made in those States which agree to match the basic 30 percent Federal grant. The Federal grant may be increased to 50 percent if the State agrees to pay at least 25 percent of the project cost and enforceable water quality standards have been established for the waters into which the project discharges. A grant may be increased by 10 percent, to 33, 44 or 55 percent, as appropriate,

if the project is certified by a metropolitan or regional planning agency as conforming with a comprehensive metropolitan area plan.

All three States in the Lake Superior basin either have legislation to qualify their municipalities for consideration for the higher grant percentages or have introduced enabling legislation into their State Legislatures. In November 1968, Michigan electors, by a three to one margin, authorized the sale of \$335 million worth of bonds for purposes of assisting communities in improving existing and constructing new waste treatment plants; \$50 million of this total bond program is to be used for sewer construction assistance for communities without sewers which are contributing to an existing pollution problem and have low property valuation. A draft copy of a State law to implement the State grant bond issue which will spell out the details of administering and funding specific projects has been completed. Passage of this legislation is expected in the near future.

Wisconsin provides financial assistance of not less than 25 percent or more than 30 percent of the cost of construction of waste treatment facilities. Wisconsin statutes authorize a sum sufficient appropriation up to \$6 million per year.

In addition to this program Governor Knowles of Wisconsin has proposed an Outdoor Resources Action Plan - 200. This plan would establish a \$200 million bonding program, of which \$144 million would be used for construction of sewage treatment facilities. The plan was approved by the citizens of Wisconsin in an advisory referendum. Implementation details are currently in progress.

In Minnesota, a \$20 million statewide bonding program to aid local communities with 30 percent of construction costs has been proposed by Governor LeVander. The State fund would be a grant to municipalities unless or until the Federal Government appropriates sufficient money to fully fund the presently authorized Federal program. At that time Federal funds going to a municipality would reimburse the State. A bill to implement this \$20 million bonding program has been introduced into the 1969 session of the Minnesota State Legislature. A second bill has been introduced into the Legislature that would provide for a \$6 million per year appropriation for State aid to municipalities. Under this proposal the local communities would be eligible to receive full financial benefit from the Federal program.

Program Grants

Section 7 of the Water Pollution Control Act authorizes an appropriation of \$10 million annually for Fiscal Years 1968-71 for grants to State and interstate agencies to assist them in meeting the costs of establishing and maintaining adequate pollution control programs. Each State is allotted \$12,000, and the remainder of the funds are distributed on the basis of population, financial need, and the extent of the water pollution problems facing the State. Since program grants were first authorized in Fiscal Year 1957, a total of \$4,433,930 in Federal funds has been allocated to the Lake Superior States for their pollution control programs. By June 1969, Michigan will have received approximately \$2,158,273; Minnesota, \$1,013,585; and Wisconsin, \$1,262,072. During the current fiscal year Michigan is allocated \$338,500; Minnesota, \$148,000; and Wisconsin, \$185,500.

Research, Development and Demonstration Grants

The Research, Development and Demonstration Program is mission oriented, employing the use of grants and contracts for investigations and demonstrations relating to the solution of problems confronting the attainment or retention of clean water. The program deals with the full range of water quality problems -- from pollution definition and control to water resources management and planning.

The Federal Water Pollution Control Act specifically authorizes projects concerned with (a) storm and combined sewers; (b) advanced waste treatment and joint treatment systems for mu-

municipal and industrial wastes; and (c) methods for prevention of pollution by industry, including treatment of industrial wastes.

In addition, research, training, demonstration, and research fellowship grants are available for the intended purpose to encourage and assist appropriate agencies, institutions, and individuals in the conduct of studies and training which will achieve clean water.

The information being gathered through the above programs will have a wide range of applicability and therefore will be of use in pollution control actions in the Lake Superior basin.

An intramural research program of the FWPCA is carried out in eight ongoing laboratories located across the country. Within the Great Lakes basin, the Administration has established the National Water Quality Laboratory at Duluth, Minnesota. The mission of this laboratory is to determine permissible limits of water quality for any water use and the impairment that can be expected if these limits are exceeded.

In addition to the above, the Federal Water Pollution Control Act specifically authorizes the Federal Water Pollution Control Administration to conduct research and technical development work, and make studies with respect to the quality of the waters of the Great Lakes.

Federal Installations

The Federal Government has not overlooked the pollution hazards created by its own activities. By Executive Order 11288, President Johnson directed the heads of the departments, agencies, and establishments of the Executive Branch of the Government to provide leadership in the nationwide effort to improve water quality.

Federal installations in the Lake Superior basin have initiated pollution abatement programs in accordance with the Order. Excluding those facilities that discharge to municipal systems there are approximately 124 installations within the basin. These are distributed as follows: Michigan 73, Minnesota 37, and Wisconsin 14. The size of the installations vary from camp and picnic grounds at Federal parks to major military installations such as Air Force Bases. These installations discharge waste after varying degrees of treatment to ground or surface waters of the basin. Some of the smaller installations provide no treatment at present. Tabulated in Appendix A of this report is an inventory of these installations showing the waste treatment provided and the status of pollution abatement.

The more significant Federal vessels which frequent the waters and the harbors of Lake Superior are also listed in the Appendix. The U.S. Coast Guard, Navy, and Army Corps of Engineers are all acutely aware of the problems associated with vessel pollution. They are actively pursuing abatement and research and development programs in an effort to obtain waste treatment devices suitable for shipboard use.

All Corps of Engineers vessels and floating plants (tugs, dredges, derricks, etc.) operating in Lake Superior have been fitted with macerator/chlorinator units. Efforts are being made to insure that these devices will be replaced with upgraded disposal units such as holding tanks at the earliest possible date.

Federal water resources projects and facilities and operations supported by Federal loans, grants, or contracts are also included in Executive Order 11288. Water resource projects must be designed, constructed, and operated in a manner which will reduce pollution from such activities to the lowest practicable level.

The head of each Federal department, agency and establishment has been directed to conduct a review of the loan, grant, and contract practices of his own organization to determine to what extent water pollution control requirements set forth in the Order should be adhered to by borrowers, grantees, or contractors. This review has resulted in practices designed to

reduce water pollution in various programs. Urban renewal projects now require the construction of separate storm and sanitary systems rather than combined sewers. The nationwide highway construction program financed with Federal funds and administered by the Bureau of Public Roads, is now being conducted in accordance with practices aimed at preventing water pollution, either during construction or in operation and maintenance. The various agencies have consulted with the Federal Water Pollution Control Administration in an effort to insure maximum consideration of water quality in their activities.

This Order represents a major step forward in the battle to preserve and enhance quality of our Nation's waters. It has sparked a keen awareness on the part of Government officials of the need for corrective action and vigorous abatement programs. The effort being shown by these various Federal agencies provides leadership in the nationwide quality improvement program.

Technical Programs

The Regional Technical Program provides technical assistance in solving pollution problems to Federal, State, and local agencies, and to industry. Current technical assistance projects affecting Lake Superior include:

1. Participation with the Corps of Engineers in a joint study of the water pollution problems associated with dredging. This includes collection and analysis of samples of bottom sediments from Lake Superior harbors.
2. Participation in the International Joint Commission study of the feasibility of further regulation of the levels of the Great Lakes, including Lake Superior. The object of such further regulation would be to reduce damages resulting from excessively high or low lake levels.
3. Participation in the Department of the Interior study concerning the effects on water quality by the discharge of taconite tailings.

The Technical Program also has responsibility for surveillance of water quality throughout the Region for purposes of water quality standards compliance, basic planning, and long-term water quality trends. A Regionwide surveillance plan is being developed in cooperation with the State water pollution control agencies which will include the streams of the basin and the lake itself.

Basin planning for water pollution control and water quality management is also a responsibility of Technical Programs. This includes inhouse planning studies, participation in the Great Lakes Basin Commission Type I, or framework study, and the administration of the planning grants program authorized by the Federal Water Pollution Control Act, as amended.

Public Information

The Public Information Program of the Federal Water Pollution Control Administration is designed to present facts about water pollution control to the news media, interested groups and organizations, and the public, generally. The program serves the public's right to know what FWPCA is doing and trying to accomplish. It also serves those who need particular information in order to participate effectively in water pollution control programs.

STATE WATER POLLUTION CONTROL PROGRAMS

Michigan, Minnesota and Wisconsin each have water pollution control programs which provide for surveillance and enforcement, surveys and special studies and long range water quality management planning activities. Their programs also include review of municipal and industrial waste treatment plant plans and specifications for conformity with Federal, State and local pollution control regulations, review of treatment plant maintenance and operation procedures and plant efficiencies and technical assistance in waste treatment problems to both municipalities and industries. Each State has a program for the certification of waste treatment plant operators and a commensurate program for the training of operators to meet certification requirements, and each State conducts a public information program for the dissemination of water pollution control news to the general public as well as special information to those professionally interested.

Michigan

The Michigan Water Resources Commission planned in Fiscal Year 1969 to continue to emphasize the enforcement of pollution abatement with subsequent water quality improvement and prevention of water quality degradation. The Commission is charged with control over the pollution of any waters of the State and the Great Lakes and to protect and conserve the water resources of the State. Michigan's plans call for expanded action in many elements of water pollution control. The program of establishing intrastate water quality standards is to be completed in Fiscal Year 1969, and with the passage of a \$335 million bond issue, the State is now able to provide 25 percent grants to municipalities for the construction of waste treatment facilities.

The State's water quality surveillance program is accelerating with plans for automated sampling analysis and data processing. Commission rule concerning watercraft pollution will go into effect January 1, 1970, and new statutory requirements for certifying industrial and commercial waste treatment operators will require a new agency program for training and certification of those operators. The Michigan Water Resources Commission chairs an interdepartmental committee on water and related land use planning.

Michigan's current fiscal year water pollution control budget is \$995,000 and approximately 74 man-years are assigned to that effort. Increases are proposed in Fiscal Year 1970 which will contribute further to the Commission's ability to assure protection of the State's waters.

In addition to the above, the Michigan Department of Public Health through its Waste Water Control Section, expends \$130,000 and approximately 12 man years on pollution control.

Minnesota

The Minnesota Pollution Control Agency has planned a program of expansion and special contracts in Fiscal Year 1969. The Agency has overall responsibility, at the State level, for managing the quality of the waters of Minnesota by controlling the sources of pollution which may adversely affect water quality. Minnesota's program includes several specific activities to improve the water pollution control effort. Effluent standards have been adopted for all waters of the State and more waters are to be monitored on a more frequent basis throughout the State. A systematic program of adopting water use classifications and establishing water quality standards is underway for intrastate waters. The State's criteria for determining priorities for Federal grants for the construction of municipal waste facilities enables better distribution of funds to areas where pollution problems are greatest. The important aspect of efficient plant operation will be improved with the planned use of regional operator training schools, although certification is not mandatory in Minnesota. A bill has been introduced into the current session of the legislature that would require mandatory certification. The Agency's plans to expand its staff and activity in all elements of the water pollution control program is a significant expression of the State's concern.

Currently Minnesota's annual water pollution control budget is \$717,476 and approximately 46 man-years are assigned to that effort. The Fiscal Year 1969 budget and the proposed Fiscal Year 1970 budget are significantly higher than previous years, and an increase over present levels of about 12 man-years is projected for Fiscal Year 1970.

Wisconsin

The Wisconsin Department of Natural Resources serves as the central unit of State government to protect, maintain and improve the quality and management of the waters of the State and to organize a comprehensive program for that purpose. Wisconsin's Fiscal Year 1969 program includes many activities which are an expansion of the State's effort. Intrastate water quality standards have been adopted and a system of effluent charges for the control of water pollution is being studied. Plans call for at least annual inspection of all municipal, industrial and State operated sewage treatment plants. The mandatory certification of waste treatment plant operators recently went into effect; and in keeping with that program, the operator training program is being significantly upgraded and expanded. As a step in a program of flood plain and shoreland management, the State is currently overseeing local administration of ordinances and development of flood plain information. The water resources planning activity is also scheduled for expansion to provide plans for each of the State's regions.

In Fiscal Year 1969 Wisconsin's water pollution control budget is \$1,879,800 and 68 man-years are assigned to that effort. Projections for Fiscal Year 1970 call for increases which will further expand the State's water pollution control effort.

V. WATER QUALITY CRITERIA

The quality of water in Lake Superior surpasses that of virtually all other major lakes of the United States. The extremely low dissolved and suspended solids, the very cold temperatures, the extreme clarity, and the high oxygen concentration of the water coupled with the size of the lake, makes a unique natural resource that has no equal in the world.

Most of the lake is uniform in nature, including such indices that normally vary seasonally; as for example, temperature and oxygen. For the most part, the dissolved materials present in the water are those that are contributed by natural causes. Present discharges from tributary streams and man-made outfalls are few in number and mostly small in size, therefore as a general rule only limited areas are adversely affected by them. Except for minimal pesticide contamination, the lake is essentially free of synthetic organic chemicals that cause so many problems in other waters. This existing exceptionally high water quality must be preserved.

Water quality standards have been adopted for Lake Superior by the Lake Superior States and approved by the Department of the Interior. The States assigned their highest use categories to Lake Superior (i.e., public water supply, whole body contact recreation, and cold water fishery). The water quality criteria adopted to protect these designated uses were established using the best available knowledge at that time. Hence, the water quality standards for Lake Superior are the most restrictive adopted by the States of Michigan, Minnesota, and Wisconsin, and are among the most stringent standards nationally.

Additional data concerning water quality criteria specific to Lake Superior waters are now available as a result of recently completed research at the FWPCA's National Water Quality Laboratory at Duluth, Minnesota. The National Technical Advisory Committee on Water Quality Criteria (46) issued a report on April 2, 1968 that provides additional information on water quality criteria. These data can be used as a guide to amend the existing water quality standards on Lake Superior. In accordance with the provisions of the Water Quality Act of 1965, it was anticipated that after the initial setting of standards periodic review and revision would be required to take into account changing technology and advances in knowledge of water quality requirements developed through research.

While data on the existing quality of Lake Superior is not abundant, there have been continuous monitoring stations operated at the Duluth water intake and on the St. Mary's River by the FWPCA's water quality monitoring system. From these activities a reasonable picture is available as to the elemental composition of the water for many of the major constituents.

On the basis of the above, water quality criteria can be developed on the open waters of Lake Superior to reflect more appropriately the uniqueness of the lake. These criteria are presented in Table 3. The rationale for these criteria are presented in Appendix C.

TABLE 3

PROPOSED WATER QUALITY CRITERIA FOR THE OPEN WATERS OF LAKE SUPERIOR¹

(Mg/l unless otherwise specified)		
Parameter	90% Value ²	Maximum Value ³
Dissolved Oxygen	>10.0	9.0
Turbidity	0.5 JTU	5.0 JTU
Color - Wavelength A ⁴	0.01 absorbance units	0.05 absorbance units
Wavelength B ⁵	0.05 absorbance units	0.25 absorbance units
Total Dissolved Solids	65.0	-
Total Coliform Bacteria	10 per 100 ml	1,000 per 100 ml
Fecal Coliform Bacteria	10 per 100 ml	200 per 100 ml
Detergents (MBAS)	0.1	0.4
Phenol	-	0.001
Ammonia Nitrogen	0.05	0.1
Phosphorus	-	0.01
Iron	0.03	0.1
Cadmium	0.002	0.005
Chromium	0.02	0.05
Copper	0.008	0.012
Lead	0.03	0.05
Nickel	0.015	0.03
Zinc	0.01	0.015
Cyanide	0.002	0.004
Hydrogen Sulfide (as total sulfide measured at bottom-water interface)	0.002	0.02
Taste and Odor - Chloroform Extracts	0.03	0.05
Threshold Odor	1.0	3.0
	<u>Mean Value</u>	<u>Maximum Value</u>
Temperature (Surface in top meter)		
January, February, March	2°C	5°C
April, May, June	10°C	18°C
July, August, September	18°C	21°C
October, November, December	8°C	15°C
Depths greater than 120 feet: Never over 6°C		
pH - Should remain between 6.8 to 8.5 units		
Radioactivity - Recommendations for proposed radiological criteria will be deferred pending development of model criteria by Federal Water Pollution Control Administration, Atomic Energy Commission, and U.S. Public Health Service.		

General: For nonpersistent wastes discharged directly to Lake Superior, and for other individual chemicals, the 90% value is 1/20 of the 96-hour TL_m value and the maximum value is 1/10 of the 96-hour TL_m value. For persistent complex wastes and other individual materials, the 90% value is 1/100 of the 96-hour TL_m value and the maximum value is 1/20 of the 96-hour TL_m value.

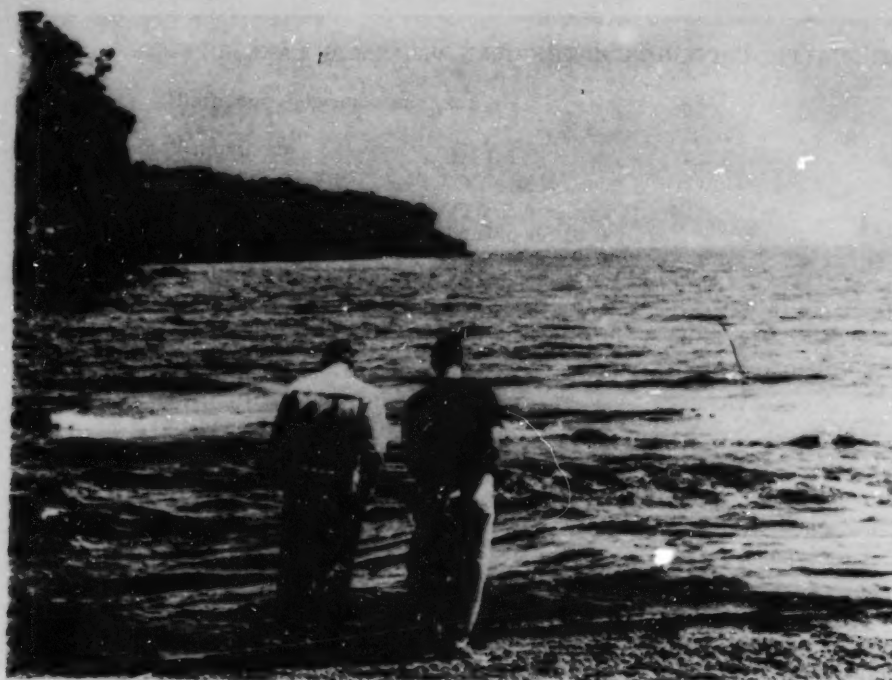
¹ Zones of tributary influence and mixing zones should not exceed a linear distance equal in feet to the cube root of the discharge in mgd x 500. In these zones other standards may be applicable but in no case can the 96-hour TL_m value be exceeded.

² 90% of the values obtained at one location must not exceed this value. (For dissolved-oxygen the stated value is a minimum.)

³ Maximum value not to be exceeded. (For dissolved-oxygen the stated value is a minimum.)

⁴ Wavelength A: 3500-8000 angstroms, 10 centimeters light path.

⁵ Wavelength B: 3400-3500 angstroms, 10 centimeters light path.



The solitude, peace and quiet beauty found in many areas around Lake Superior refreshes the spirit of those who seek it.

VI. SUMMARY AND CONCLUSIONS

1. Lake Superior is a priceless natural heritage which the present generation holds in trust for posterity, with an obligation to pass it on in the best possible condition.
2. The esthetic value of Lake Superior is of major importance. The lake's deep blue appearance is a significant tourist attraction.
3. Because of the low mineral content of Lake Superior's waters, increases in the range of 2 to 50 parts per billion of heavy metals such as copper, chromium, zinc, and cadmium will have lasting deleterious effects upon the lake.
4. The extreme clarity and cold temperature of the waters of Lake Superior are a necessity to support its present ecology. A reduction in light penetration will significantly alter the types of life therein. The clarity of the lake is extremely susceptible to being reduced by pollutants.
5. The portion of Lake Superior shallow enough to provide suitable fish spawning areas is limited to a small band around the shoreline. This area is most susceptible to the influence of natural and man-made sediments. Deposition on the bottom of fine particles discharged to Lake Superior is a threat to the inshore food producing area and to the incubation of important fish species.
6. Water quality criteria can be established to protect the esthetic value, recreational uses and the unique aquatic life of the lake and yet such that reasonable allowance is made for future municipal and industrial expansion.
7. Lake Superior is an oligotrophic lake. Nutrient values in some area of the lake have been reported at levels approaching those commonly associated with nuisance algal growths. However, other factors, such as temperature, are limiting.
8. Outflow from Lake Superior passes through Lakes Huron, Erie and Ontario. Dissolved chemicals in this outflow contribute to the levels found in these downstream lakes.
9. The discharge of taconite tailings to Lake Superior from the Reserve Mining Company, E. W. Davis Works, has a deleterious effect on the ecology of a portion of the lake by reducing organisms necessary to support fish life.
10. The quantity of oxygen normally dissolved in water is one of the more important ingredients necessary for a healthy balanced aquatic life. The discharge of treated and untreated municipal and industrial wastes with high concentrations of biochemical oxygen demand has caused oxygen depletion in the St. Louis River, Duluth - Superior harbor, and Montreal River.
11. Watercraft plying the waters of Lake Superior are contributors of both untreated and inadequately treated wastes in local harbors and in the open lake, and intensify local pollution problems.
12. Oil discharges from industrial plants, commercial ships and careless loading and unloading of cargoes despoil beaches and other recreational areas, coat the hulls of boats and are deleterious to fish and aquatic life.
13. Evidence of bacterial pollution has been reported in the St. Louis River, and Duluth Harbor area in Minnesota; and Superior Harbor area, Ashland inshore area and reaches of the Montreal River in Wisconsin.
14. The maintenance of waterways for commercial and recreational use is a necessary activity. The deposition of polluted dredgings contributes to the degradation in quality of Lake Superior.

15. Adverse effects upon water quality and water uses of streams in the red clay area of northwestern Wisconsin is occurring as a result of land runoff from poor land management practices. The sediment contained in the discharges from streams in this area has an adverse effect on Lake Superior.

16. A persistent pollutant entering directly into the waters of Lake Superior or dissolved in the water that feeds the lake mixes with and becomes an integral part of a significant portion of the lake water.

17. Discharges of wastes originating in Michigan and Wisconsin cause pollution of the interstate Montreal River. Discharges of wastes originating in Minnesota and Wisconsin cause pollution in the interstate St. Louis River and Duluth - Superior harbor. These discharges endanger the health or welfare of persons in States other than those in which such discharges originate. This pollution is subject to abatement under the provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et. seq.).



We conserve so that our own and future generations
will be able to enjoy...

Congressman Wayne N. Aspinall
Colorado

VII. RECOMMENDATIONS

It is recommended that:

1. Water quality criteria as shown in Table 3 (page 14) be included as part of the interstate water quality standards on Lake Superior to reflect more appropriately the uniqueness of the lake.
2. The FWPCA and the States keep the discharge of taconite tailings to Lake Superior from the Reserve Mining Company, E.W. Davis Works, under continuing surveillance and report to the conferees at six month intervals on any findings that interstate pollution is occurring or is likely to occur, and the State of Minnesota is urged to take such regulatory actions as necessary to control the intrastate pollution resulting from these discharges, if any.
3. The FWPCA and the States adjust or modify water quality surveillance plans for the Lake Superior basin to insure that plans are sufficiently sensitive to monitor changes in water quality. The FWPCA and States are requested to report to the conferees within six months concerning their program.
4. Secondary biological waste treatment be provided by all municipalities in the Lake Superior basin. This action is to be accomplished by January 1973 or earlier if required by Federal-State water quality standards.
5. Continuous disinfection be provided throughout the year for all municipal waste treatment plant effluents. This action should be accomplished as soon as possible and not later than May 1970.
6. Continuous disinfection be provided for industrial effluents containing pathogenic organisms which indicate the presence of such pathogens. This action should be accomplished as soon as possible and not later than May 1970.
7. Waste treatment be provided by municipalities to achieve at least 80 percent reduction of total phosphorus from each State. This action is to be accomplished by January 1973, or earlier if required by Federal-State water quality standards.
8. Industries not connected to municipal sewer systems provide treatment equivalent to that of municipalities so as not to cause the degradation of Lake Superior water quality. This action is to be accomplished by January 1973 or earlier if required by Federal-State water quality standards.
9. Each State water pollution control agency make necessary corrections to the list in Appendix A of municipal and industrial waste discharges to the Lake Superior basin. In addition, information should be provided on each source to indicate whether it discharges pollutants, including nutrients, that have a deleterious effect on Lake Superior water quality. Detailed action plans for treatment of all wastes having deleterious effects should be developed, where not already completed. Such plans shall identify the principal characteristics of the waste material now being discharged, the quantities, the proposed program for construction or modification of remedial facilities and a timetable for accomplishment, giving target dates in detail. This list shall be presented to the conferees within six months.
10. Unified collection systems serving contiguous urban areas be encouraged.
11. Each of the State's water pollution control agencies accelerate programs to provide for the maximum use of area-wide sewage facilities to discourage the proliferation of small treatment plants in contiguous urbanized areas and foster the replacement of septic tanks with adequate collection and treatment.

12. Each State water pollution control agency list the municipalities or communities having combined sewers. The listing should include a proposed plan for minimizing bypassing so as to utilize to the fullest extent possible the capacity of interceptor sewers for conveying combined flow to treatment facilities. Construction of separate sewers or other remedial action to prevent pollution from this source is to be completed by October 1977.
13. Existing combined sewers be separated in coordination with all urban reconstruction projects except where other techniques can be applied to control pollution from combined sewer overflows. Combined sewers should be prohibited in all new developments.
14. Discharge of treatable industrial wastes to municipal sewer systems be encouraged.
15. The States institute necessary controls to ensure that the concentration of DDT in fish not exceed 1.0 micrograms per gram; DDD not exceed 0.5 micrograms per gram; Dieldrin not exceed 0.1 micrograms per gram and all other chlorinated hydrocarbon insecticides, singly or combined, should not exceed 0.1 micrograms per gram. Limits apply to both muscle and whole body and are expressed on the basis of wet weight of tissue.
16. Uniform State rules and regulations for controlling wastes from watercraft should be adopted. These rules and regulations should generally conform with the rules and regulations approved by the conferees to the Lake Michigan - Four State Enforcement Conference. Commensurate interstate requirements controlling the discharge of wastes from commercial vessels should be the responsibility of the Federal Government.
17. The dumping of polluted dredged material into Lake Superior be prohibited.
18. Programs be developed by appropriate State and Federal agencies to control soil erosion in the basin. The action plan developed by the Red Clay Interagency Committee should become an integral part of the programs conducted by all appropriate agencies, groups and private individuals.
19. The discharge of visible oil from any source be eliminated.
20. The recommendations of this enforcement conference be adopted as part of the States' enforceable water quality standards.

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APPENDIX A

Information contained in the following tables of waste discharges are as currently known to the Federal Water Pollution Control Administration. No interpretation of the adequacy or inadequacy of the existing treatment or the abatement schedule is made.

STATUS OF MUNICIPAL WASTE DISCHARGES

(As of March 1, 1969)

MICHIGAN

<u>COMMUNITY OR DISTRICT</u>	<u>TYPE OF TREATMENT (EXISTING)</u>	<u>WHERE DISCHARGED</u>	<u>ABATEMENT SCHEDULE</u>
Ahmeek	None	Hills Creek	
Allouez Twp.	None	Hills Creek	
Baltic	Primary	Br. of Pilgrim River	
Baraga	Primary	Lake Superior	
Bergland	None	Lake Gogebic	
Bessemer	Secondary	Kallander Creek	
Big Bay	Primary	Lake Independence	
Bruce Crossing	None	Clear Creek	
Calumet	Secondary	Ground waters	
Chatham	None	Slapneck Creek	
Copper City	Primary	Trap Rock River	
Erwin Twp.	Secondary	Ground waters	
Ewen	None	So. Br. of Ontonagon River	
Florida	None	Hammell Creek	
Gay	Primary	Tobacco River	
Houghton - Hancock	Secondary	Portage Lake	
Hubbell	None	Torch Lake	
Ironwood	Secondary	Montreal River	
Ironwood Twp.	Secondary	Welch Creek	
Ishpeming	Primary	Carp River	
Ishpeming Twp. A.	Primary	Carp River	
Ishpeming Twp. B.	Primary	Carp River	
Lake Linden	None	Torch Lake	
L'Anse	Secondary	Linden Creek	
Laurium	Primary	Hammell Creek	
Marenisco	None	Presque Isle River	
Marquette	Primary	Carp River	
Mass-Greenland	None	Flintsteel River	
Mohawk	None	Hills Creek	
Munising	Primary	Anna River	
Negaunee	Secondary	Ditch	
Newberry	Primary	Tahquamenon River	
Ontonagon	Primary	Ontonagon River	
Painesdale	None	Ditches	
Portage Twp.	None	Huron Creek	
Ramsay	None	Black River	
Rockland	None	Rockland Creek	
South Range	Primary	Br. of Pilgrim River	
Trout Creek	None	Trout Creek	
Wakefield	Secondary	Planter Creek	
Watersmeet	Primary	Middle Branch of Ontonagon River	
White Pine	Secondary	Mineral River	

STATUS OF INDUSTRIAL WASTE DISCHARGES

(As of March 1, 1969)

MICHIGAN

<u>INDUSTRY AND LOCATION</u>	<u>TYPE OF TREATMENT (EXISTING)</u>	<u>WHERE DISCHARGED</u>	<u>ABATEMENT SCHEDULE¹</u>
Bancroft Dairy Marquette	Septic tank	Dead River via Unnamed Creek	E
Royal Oak Charcoal Marquette	Oil and tar separator San. - city sewers	Lake Superior	B
Bosch Brewing Houghton	Hops removed Label screen on bottle washer San. - septic tanks and tile field	Portage Lake	B
Kimberly Clark Munising	Chem. precip. & settling. San. - city sewers	Lake Superior	B
Calumet and Hecla Osceola Mine Calumet	None	Hammel Creek to Torch Lake	B
Cleveland Cliffs Iron Eagle Mills	Seepage Lagoon		A
White Pine Copper White Pine	San. sewage from Tolfrey Shaft Chem. precip. and lagoon San. sewage Sec. treat. & Cl ₂	Argentine and Tolfrey Cr. Native Cr. and Mineral River - Lake Superior Mineral River - Lake Superior	A A
Hoerner-Waldorf, Inc. Huss-Ontonagon Mill Division Ontonagon	Save-all, San. - city sewer	Ontonagon River	E

STATUS OF INDUSTRIAL WASTE DISCHARGES

(As of March 1, 1969)

MICHIGAN
(CONTINUED)

<u>INDUSTRY AND LOCATION</u>	<u>TYPE OF TREATMENT (EXISTING)</u>	<u>WHERE DISCHARGED</u>	<u>ABATEMENT SCHEDULE¹</u>
Ontonagon Valley Coop. Creamery Bruce Crossing	Haul whey	Clear Creek and Baltimore River	B
Celotex Corporation L'Anse	Spray irrigation	Ground water	A
Superior Packing Ironwood		Ground water	B
Somer's Slaughterhouse Newberry		Ground water	B
Board of Power and Light Marquette	Cooling water - None	Lake Superior	A
	Ash disposal - Lagoon	Lake Superior	
U. P. Generating Co. Marquette	Cooling water - None	Lake Superior	A
	Ash disposal - Lagoon	Dead River	
U. P. Power Co. L'Anse	Cooling water - None	Falls River and Lake Superior	A
Lake Superior Engineer- ing Company Winona	Seepage Lagoon		B
Northern Automatic Elec. Foundry Ishpeming	Cooling and settling ponds	Carp River	B

- ¹ A - Control adequate
 B - Control provided - adequacy not established
 C - No control - need not established
 D - Control provided - protection unreliable
 E - Control inadequate

STATUS OF MUNICIPAL WASTE DISCHARGES

(As of March 1, 1969)

MINNESOTA

<u>COMMUNITY OR DISTRICT</u>	<u>TYPE OF TREATMENT (EXISTING)</u>	<u>WHERE DISCHARGED</u>	<u>ABATEMENT SCHEDULE</u>
Aurora	Secondary	Creek to St. Louis River	
Babbitt	Secondary	Embarrass River	
Biwabik	Secondary	Embarrass Lake	
Buhl	Secondary	Buhl Creek to East Swan River	
Carlton	Primary	St. Louis River	12-18-71
Chisholm	Secondary	Chisholm Creek to East Swan River	
Cloquet	Primary	St. Louis River	11-12-73
Duluth - Main Plant	Primary	St. Louis Bay	6-18-71
Duluth - Fairmont Park	Primary	St. Louis River	6-18-71
Duluth - Gary-New Duluth	Primary	St. Louis River	6-18-71
Duluth - Smithville	Primary	St. Louis River	6-18-71
Eveleth	Secondary	Creek to Elbow Lake	
Floodwood	None	Floodwood River	12-18-71
Franklin	Primary	Mine Cave	
Fraser	Secondary	Creek to Six Mile Lake	
Gilbert	Secondary	Ditch to Horseshoe Lake to Embarrass River	
Grand Marais	Primary	Lake Superior	12-18-71
Hibbing	Secondary	Hibbing Creek to East Swan River	
Hoyt Lakes	Secondary	Lower Partridge Lake	
Iron Junction	Primary	Creek to St. Louis River	
Kelly Lake	Secondary	West Swan River	
St. Louis County			
Kinney	Primary	Creek to McQuade Lake to W. Two Rivers	
Leonidas	Primary	Creek to St. Louis River	
McKinley	Primary	McKinley Lake and Cr. to Embarrass River	
Meadowlands	Secondary	Cr. to Whiteface River	
Mountain Iron	Secondary	Cr. to West Two Rivers	
Nichols Twp.	Secondary	Creek to Mashkenode Lake	
St. Louis County			
Proctor	Duluth sewer system, Fairmont Park Plant		
Scalon	Primary	St. Louis River	12-18-71
Silver Bay	Secondary	Lake Superior	6-18-72
Taconite Harbor	Secondary	Lake Superior	
Cook County			
Thompson Twp. - Esko	Secondary	Midway River	
Corner Carlton County			
Two Harbors	Primary	Agate Bay - Lake Superior	12-18-71
Virginia	Secondary	East Two Rivers to Three Mile Lake	
Wrenshall	Secondary	Ravine to Silver Brook to St. Louis River	
Nopeming Sanatorium	Secondary	Ditch to Mission Creek	
Duluth, Minnesota			

STATUS OF INDUSTRIAL WASTE DISCHARGES

(As of March 1, 1969)

MINNESOTA

<u>INDUSTRY AND LOCATION</u>	<u>TYPE OF TREATMENT (EXISTING)</u>	<u>WHERE DISCHARGED</u>	<u>ABATEMENT SCHEDULE</u>
Minnesota Power and Light Co. Duluth	Pneumatic ash system	St. Louis Bay	
Superwood Co. Duluth	Settling pond	Superior Bay	12-18-71
U. S. Steel Co., Duluth Works Duluth	Oil and solids removal pond, spent acid disposal pit	St. Louis Bay	12-18-71 ¹
Arrowhead Blacktopping Duluth	Oil trap	Sargent Creek to St. Louis Bay	
R. J. Reynolds Foods, Inc. Duluth	Process waste - Mun. Cooling and retort waste - none	Swamp to St. Louis Bay	
Arrowhead Sand and Gravel Co. Duluth	Tailings basin	Sullivan Creek	
Two Harbors Power Plant Two Harbors		Lake Superior	
Reserve Mining Co. E. W. Davis Works Silver Bay	None	Lake Superior	12-18-71
Erie Mining - Taconite Harbor Power Plant Taconite Harbor	Pneumatic ash system	Lake Superior	
U. S. Customs and Immigration Pigeon River	Secondary	Pigeon River	
Continental Oil Co. Wrenshall	A. P. I. oil separator, oil removal pond, seepage pond, steam strippers, spent caustic recovery aeration ponds	Silver Creek to St. Louis River	
Northwest Paper Co. Cloquet	Screens and flota- tion save-all, lime sludge ponds, clari- fier, sulfite liquor for road binder	St. Louis River	11-12-73

¹Final date for suspended solids, oil and turbidity reduction. An additional year may be granted for other construction needed.

STATUS OF INDUSTRIAL WASTE DISCHARGES

(As of March 1, 1969)

MINNESOTA
(CONTINUED)

<u>INDUSTRY AND LOCATION</u>	<u>TYPE OF TREATMENT (EXISTING)</u>	<u>WHERE DISCHARGED</u>	<u>ABATEMENT SCHEDULE</u>
Conwed Corporation Cloquet	Fine screens, hot pond settling basin	St. Louis River	11-12-73
Oglebay Norton Co. Fairlane Plant Forbes	Closed tailings basin system Sanitary-secondary	Emergency discharge only to St. Louis River Swamp to St. Louis River	
The Hanna Mining Co. Agnew, Hibbing	Closed tailings basin system		
The Hanna Mining Co. Natl. Steel Pellet Project, Kewatin	Closed tailings basin system		
The Hanna Mining Co. Pierce Group Hibbing	Closed tailings basin system		
Jones and Laughlin Steel Corp. - McKinley McKinley	Closed tailings basin system		
Jones and Laughlin Steel Corporation - Schley Group Gilbert	Closed tailings basin system		
Coons Pacific Co. Coons Pacific Plant Eveleth	Closed tailings basin system		
Pickands Mather and Co. Erie Commercial Hoyt Lakes	Closed tailings basin system		
Pickands Mather and Co. Mahoning Hibbing	Closed tailings basin system		
Rhude and Fryberger Gross - Nelson Eveleth	Closed tailings basin system		
Rhude and Fryberger Hull - Rust Hibbing	Closed tailings basin system		
U. S. Steel Corp. Minntac Mountain Iron	Closed tailings basin system		
U. S. Steel Corp. Rochleau Group Virginia	Closed tailings basin system		
U. S. Steel Corp. Sherman Group Chisholm	Closed tailings basin system		

STATUS OF MUNICIPAL WASTE DISCHARGES

(As of March 1, 1969)

WISCONSIN

<u>COMMUNITY OR DISTRICT</u>	<u>TYPE OF TREATMENT (EXISTING)</u>	<u>WHERE DISCHARGED</u>	<u>ABATEMENT SCHEDULE</u>
Ashland	Primary	Lake Superior	10-1-70
Bayfield	Primary	Lake Superior	10-1-70
Hurley	Primary	Montreal River	10-1-70
Knight, Tn. of	Primary	Iron Belt Trib.	10-31-69
Iron River	Primary	Iron River	10-31-69
Mellen	Primary	Bad River	10-1-70
Montreal	Primary	West Fk. Montreal River	10-1-70
Pence	Primary	Pence Tributary	10-31-69
Port Wing, Tn. of	Lagoon	Tributary of Flag River	
Saxon	None	Swamp of Vaughn Cr.	10-31-69
Superior	Primary	Lake Superior	10-1-70
Superior Village	Secondary	Pokegama River	
Washburn	Primary	Lake Superior	10-1-70
Ondassagon School Ashland, Wisconsin		Whittlesey Creek	9-1-69
Pureair Sanatorium Bayfield, Wisconsin		Drainage Course	10-31-68

STATUS OF INDUSTRIAL WASTE DISCHARGES

(As of March 1, 1969)

WISCONSIN
(CONTINUED)

<u>INDUSTRY AND LOCATION</u>	<u>TYPE OF TREATMENT (EXISTING)</u>	<u>WHERE DISCHARGED</u>	<u>ABATEMENT SCHEDULE</u>
Twin Ports Dairy Benoit	None	South Fork Fish Creek	10-31-68
Martens Dairy Cornucopia	None	Siskiwit River	10-31-68
Fuhrman South Shore Dairy Iron River	Septic tank, hauling	No discharge	10-31-68
Great Northern Allouez Superior	Separator	Bluff Creek to Lake Superior	10-31-68
Koppers Superior	Lagoon	No discharge	
Murphy Oil Superior	Separator & lagoons	Newton Creek	10-31-70
Soo Line Railroad Superior	None	Soo Line Drainage to Lake Superior	10-31-68
Great Northern Railroad Superior	Separator & lagoons	Great Northern Drainage to Lake Superior	10-31-68
Union Tank Car Superior	Septic tanks	No discharge	
Superior Fiber Products Superior	Chemical and screening	Lake Superior	10-1-70
Mason Milk Products Mason	Septic tank and lagoon	No discharge	
Andersonville Coop Ashland	None	Little Beartrap Creek	10-31-68
American Can Ashland	Chemical treatment & Clarification	Lake Superior	10-1-70
Lake Superior District Power Company Ashland	None	Lake Superior	
Moquah Cheese Moquah	Hauling	Moquah Cheese Factory tributary	
Bodin Fisheries Bayfield	Sanitary to Bayfield	Lake Superior	10-31-68
E. I. duPont de Nemours Barksdale	Irrigation	Boyd Creek to Lake Superior	9-1-70

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

LEGEND: S - Sanitary Wastes; I - Industrial Wastes; G - Ground or Subsurface Discharge;
P - Persons

Treatment Provided: ST - Septic Tank; DF - Drain Field; Sec. - Secondary Treatment;
Pri. - Primary Treatment; C12 - Chlorination (effluent)

Ratings: A - Adequate treatment; B - Inadequate treatment, abatement program
progressing; C - Inadequate treatment, no action taken; D - Adequacy uncertain

* Pit or vault toilets

** Schedule unmanning and automation data

*** Estimated maximum

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MICHIGAN					
U. S. Coast Guard					
Grand Marais Station Grand Marais (Alger Co.)	.70 S	G	ST, DF	A	
Whitefish Point Light Station Whitefish Point (Chippewa Co.)	11 P - S	G	ST, DF	A	
Keweenaw Lower Entrance Light Station (Houghton Co.)	11 P - S	Lake Superior	Sec, C12	A	Treatment facilities installed in 1964
Portage Station Hancock (Houghton Co.)	32 P - S	G	ST, DF	A	New treatment fac- ilities installed 1967
Manitou Island Light Station (Keweenaw Co.)	5 P - S	G	ST, DF	A	New drain field in- stalled in 1964
Passage Island Light Station (Keweenaw Co.)	5 P - S	Lake Superior	ST	B	** 1976
Rock of Ages Light Station (Keweenaw Co.)	5 P - S	Lake Superior	None	B	** 1972 The Coast Guard has submit- ted FY 70 project for installing incin- eration type toilet as an interim meas- ure pending unman- ning and automation. (Est. Cost - \$1,000)
Eagle Harbor Light Station Eagle Harbor (Keweenaw Co.)	7 P - S	Lake Superior	Sec, C12	A	Treatment facilities installed in June 1964
Huron Island Light Station West Huron Island (Marquette Co.)	5 P - S	Lake Superior	Sec, C12	A	Treatment facilities installed in June 1964

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
<u>MICHIGAN</u>					
<u>Department of Agriculture - Forest Service - Hiawatha National Forest</u>					
(C - Campgrounds) (P - Picnic Sites)					
AuTrain Lake Picnic Area (Alger Co.) (10 P)	50 P - S	G	None		*
Bay Furnace Campground (Alger Co.) (24 C)	120 P - S	G	None		*
Bay View Campground (Chippewa Co.) (24 C)	120 P - S ***	G	None		*
Big Pine Picnic Area (Chippewa Co.) (14 P)	70 P - S	G	None		*
Monacle Lake Camp, Picnic Ground (Chippewa Co.) (59 C, 12 P)	355 P - S	G	None		*
Three Lakes Camp, Picnic Ground (Chippewa Co.) (48 C, 6 P)	270 P - S	G	None		*
Raco Ranger Dwelling and Office Raco (Chippewa Co.)	0.3 S	G	ST, DF	A	
Upper Michigan Experimental Forest, Dukes (Marquette Co.)	0.3 S	G	ST, DF	A	
Dukes Warehouse One, Dukes (Marquette Co.)	0.03 S	G	ST, DF	A	
<u>Ottawa National Forest</u>					
Sturgeon River Campground (Baraga Co.) (9 C)	45 P - S	G	None		*
Bobcat Lake Camp, Picnic Ground (Gogebic Co.) (12 C, 11 P)	115 P - S	G	None		*
Burned Dam Campground (Gogebic Co.) (6 C)	30 P - S	G	None		*

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MICHIGAN					
<u>Department of Agriculture - Forest Service - Ottawa National Forest, Cont'd.</u>					
Clark-Helen Day Use Area - Sylvania Campground and Recreation Area (Gogebic Co.)	150 P - S 24.0 - S (future)	G G	None		* Plans call for construction of sewer system, sewage lagoon and spray irrigation system concurrent with site development
Ojibway Job Corps Center Marenisco (Gogebic Co.)	15.0 - S	Wellington Cr. (Presque Isle R.)	Sec., Pol- ishing Lagoon, Cl ₂ (91% BOD removal)	A	2 - 17,000 gpd ex- tended aeration package sewage treatment plants; 60 to 90-day lagoon.
Taylor Lake Campground (Gogebic Co.)	105 P - S	G	None	*	
Marion Lake Campground (Gogebic Co.)	220 P - S	G	None	*	
Henry Lake Campground (Gogebic Co.) (11 C)	55 P - S	G	None	*	
Imp Lake Camp, Picnic Ground (Gogebic Co.) (22 C, 8 P)	150 P - S	G	None	*	
Langford Lake Camp, Picnic Ground (Gogebic Co.) (11 C, 6 P)	85 P - S	G	None	*	
Matchwood Tower Campground (Gogebic Co.) (5 C)	25 P - S	G	None	*	
Moosehead Lake Campground (Gogebic Co.) (13 C)	65 P - S	G	None	*	
Pomeroy Lake East Picnic Ground (Gogebic Co.) (3 P)	15 P - S	G	None	*	

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1960)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MICHIGAN					
<u>Department of Agriculture - Forest Service - Ottawa National Forest, Cont'd.</u>					
Pomery Lake North Campground (Gogebic Co.) (19 C)	95 P - S	G	None	*	
Pomeroy Lake, West Picnic Ground (Gogebic Co.) (2 P)	10 P - S	G	None	*	
Potawatomi and Gorge Falls Picnic Ground (Gogebic Co.) (8P)	40 P - S	G	None	*	
Bob Lake Camp, Picnic Ground (Houghton Co.) (17 C, 9P)	130 P - S	G	None	*	
Lower Dan Campground (Houghton Co.) (7 C)	35 P - S	G	None	*	
Sparrow Rapid Campground (Houghton Co.) (6 C)	30 P - S	G	None	*	
Kenton Dwelling Nos. 1, 2 & 3 (Houghton Co.)	1.2 S	G	ST, DF	B	The Forest Service has developed preliminary plans to connect the dwellings sanitary wastes to the Kenton Ranger Station sewage treatment facilities. These plans have been reviewed and approved by FWPCA and State of Mich. (Est. Cost - \$20,000.)
Kenton Ranger Station (Houghton Co.)	.8 S	Ontonagon Riv. (Lake Superior)	Sec., sand filter, C12		2,000 gpd package treatment plant, sand filter trench, chlorine contact tank, & chlorination facilities installed in 1966

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MICHIGAN					
<u>Department of Agriculture - Forest Service - Ottawa National Forest, Cont'd.</u>					
Lake Ste. Kathryn Camp & Picnic Ground (Iron Co.) (35 C, 2P)	185 P - S	G	None	*	
Norway Lake Camp, Picnic Ground (Iron Co.) (28 C, 15 P)	215 P - S	G	None	*	
Perch Lake Campground (Iron Co.) (20 C)	100 P - S	G	None	*	
Perch River Picnic Ground (Iron Co.) (4 P)	20 P - S	G	None	*	
Tepee Lake Camp, Picnic Ground (Iron Co.) (17 C, 10 P)	135 P - S	G	None	*	
Courtney Lake Camp, Picnic Ground (Ontonagon Co.) (16 C, 15 P)	155 P - S	G	None	*	
Steusser Lake Picnic Ground (Ontonagon Co.)	55 P - S	G	None	*	
Paulding Pond Camp, Picnic Ground (Ontonagon Co.) (4 C, 2 P)	30 P - S	G	None	*	
Robins Pond Campground (Ontonagon Co.) (4 C)	20 P - S	G	None	*	
Black River Campground (Ontonagon Co.) (55 P) (Boat docking facilities)	12,0 S	G	ST	B	The Forest Service has submitted FY 71 project for replacing septic tank with aerated lagoon and spray irrigation system. FWPCA and State have approved engineering report and preliminary plans. Est. Cost \$280,000

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MICHIGAN					
Department of Agriculture - Forest Service - Ottawa National Forest, Cont'd.					
Bergland Dwelling No. 1 Bergland (Ontonagon Co.)	.24 S	G	ST, DF	A	
Bergland Dwelling No. 2 Bergland (Ontonagon Co.)	.20 S	G	ST, DF	A	
Bergland Ranger Station Office Bergland (Ontonagon Co.)	.20 S	G	ST	B	The Forest Service has submitted FY 71 project for replacing existing septic tank and installing tile field (Est. Cost \$1,000); construction to start in spring 1969. Est. completion date June 30, 1969

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer system.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MICHIGAN					
U. S. Army					
Lucas Camp Target Range, Raco (Chippewa Co.)	25 P - S	G	None		*
U. S. Air Force					
Calumet Air Force Station Ahmeek (Keweenaw Co.)	32.0 S	Ditch to Creek to Lake Superior	Sec, Cl ₂		Contact stabilization package sewage treatment plant (30,000 gpd) being installed to supplement the exist. overload 6,000 gpd plant. The State will require nutrient reduction by 1972. Const. completion - May 1969.
K. I. Sawyer Air Force Base Republic (Marquette Co.)	668.0 S	Silver Lead Creek (Trib. to L. Sup.)	Sec. - Effluent: BOD - 84 mg/l 64% removal S.S. - 47 mg/l 73% removal	B	The existing treatment plant is hydraulically overloaded and has been cited by Michigan Dept. of Health and Michigan Water Resources Commission as contributing to the pollution of Silver Lead Creek, which waters the State has designated as a trout stream. The Air Force, in 1965 developed a preliminary set of plans for the remedial measures necessary (Cont'd on page 70)

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rat- ing	Remarks
MICHIGAN U.S. Air Force - Cont'd. K. I. Sawyer Air Force Base Republic (Marquette Co.)					to meet the State requirements. However, due to budget limitations and the more restrictive effluent standards imposed by the State (Min. 80% phosphate removal and 5-day BOD, Max. 65 lbs./day), the Air Force is making revisions to the original design to provide the necessary facilities. The State's compliance date for the above work is 1972. Contract was let on Oct. 21, 1968 for limited modification and improvements to existing primary & secondary treatment units (sludge handling and digestion improvements, weir replacement, new laboratory, oil skimmer, chlorine bldg. chlorine contact, new filter media). Cost \$233,000. Est. completion date - Nov. 1969. Tertiary treatment project has not yet been programmed.

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(as of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MICHIGAN					
U.S. Air Force - Cont'd.					
K. I. Sawyer Air Force Base, Cont'd. Republic (Marquette Co.)	.5 S .11 I	G G	ST, DF Holding and set- tling tanks with oil skim- ming devices and lagoon	A B	The Air Force has submitted FY 70 project for connecting the in- dustrial waste discharge to the Base sanitary sewer system. This work cannot be accomplished, however, until the implementa- tion of the above plans. Est. Cost \$59,000.
Dept. of the Interior - Bur. of Sports Fisheries & Wildlife					
Pendills Creek National Fish Hatchery, Brimley (Chippewa Co.)	5,750 I	Pendills Creek to Lake Superior	None	D	Fish hatchery effluent from fish rearing tanks.
	0.7 S	G	ST, DF	A	
Hiawatha Forest Fish Hatchery Raco (Chippewa Co.)	4,220 I	Sullivans Creek to Lake Superior	None	D	Fish hatchery effluent from fish rearing tanks.
	0.15 S	G	ST, DF	A	
Dept. of the Interior - National Park Service - Isle Royale National Park					
Rock Harbor Lodge (Keweenaw Co.)	1.8 S	G	ST, DF	A	
Mott Island Headquarters (Keweenaw Co.)	0.8 S	G	ST, DF	A	
Windigo Lodge (Keweenaw Co.)	1.0 S	G	ST, DF	A	
CP Siskiwit Campground (Keweenaw Co.)	1 P - S	G	None		

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MICHIGAN					
Dept. of the Interior - National Park Service - Isle Royale National Park Cont'd					
Beaver Island (Keweenaw Co.)	1 P - S	G	None	*	
Belle Island Campground (Keweenaw Co.)	1 P - S	G	None	*	
Birch Island (Keweenaw Co.)	1 P - S	G	None	*	
Washington Creek Campground (Keweenaw Co.)	3 P - S	G	None	*	
Todd Harbor Campground (Keweenaw Co.)	1 P - S	G	None	*	
Tobin Harbor Campground (Keweenaw Co.)	3 P - S	G	None	*	
Moskey Basin Campground (Keweenaw Co.)	2 P - S	G	None	*	
Rock Harbor Campground (Keweenaw Co.)	1 P - S	G	None	*	
Merritt's Lane Campground (Keweenaw Co.)	1 P - S	G	None	*	
Malone Bay Campground (Keweenaw Co.)	3 P - S	G	None	*	
McCargo Cove Campground (Keweenaw Co.)	2 P - S	G	None	*	
Grace Island Campground (Keweenaw Co.)	1 P - S	G	None	*	
Duncan Narrows Campground (Keweenaw Co.)	1 P - S	G	None	*	
Duncan Bay Campground (Keweenaw Co.)	1 P - S	G	None	*	
Daisy Farm Campground (Keweenaw Co.)	4 P - S	G	None	*	
Chippewa Harbor Campground (Keweenaw County)	2 P - S	G	None	*	
Caribou Island (Keweenaw Co.)	1 P - S	G	None	*	

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MINNESOTA					
U. S. Coast Guard					
North Superior Station Grand Marais (Cook Co.)	9 P - S	G	ST, DF	A	
Split Rock Light Station (Lake Co.)	8 P - S	G	ST, DF	A	
Duluth Light Station Duluth (St. Louis Co.)	4 P - S	Lake Superior	None	B	** 1977. The Coast Guard has submitted FY 70 project for installing incineration type toilets as an interim measure prior to unmanned automation. (Est. Cost \$1,500.)
Department of Agriculture - Forest Service					
Superior National Forest					
Sawbill Lake Camp, Picnic Ground (Cook Co.) (50 C, 2 P)	260 P - S	G	None	*	
Temperance River Camp Ground (Cook Co.) (8 C)	40 P - S	G	None	*	
Ox-Bow Campground (Cook Co.) (3 C)	15 P - S	G	None	*	
Baker Lake Campground (Cook Co.) (4 C)	20 P - S	G	None	*	
Crescent Lake Campground (Cook Co.) (43 C)	215 P - S	G	None	*	
Boulder Lake Picnic Ground (Cook Co.) (2 P)	10 P - S	G	None		* The Forest Service has requested that this picnic ground be discontinued.
Lichen Lake Picnic Ground (Cook Co.) (1 P)	5 P - S	G	None		* The Forest Service has requested that this picnic ground be discontinued.

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MINNESOTA					
Department of Agriculture - Forest Service - Superior National Forest, Cont'd.					
Upper Poplar River Camp Ground (Cook Co.) (4 C)	20 P - S	G	None	*	
Pike Lake Picnic Ground (Cook Co.) (5 P)	25 P - S	G	None	*	
Upper Cascade River Picnic Ground (Cook Co.) (2 P)	10 P - S	G	None	*	
Two Island Lake Campground (Cook Co.) (39 C)	195 P - S	G	None	*	
Devil Track Lake Campground (Cook Co.) (18 C)	90 P - S	G	None	*	
East Bearskin Campground (Cook Co.) (47 C)	235 P - S	G	None	*	
Flour Lake Campground (Cook Co.) (44 C)	220 P - S	G	None	*	
Kimball Lake Campground (Cook Co.) (7 C)	35 P - S	G	None	*	
Tofte Administrative Site (Cook Co.)	17 P - S (75 P in future)	G	ST, DF	B	The Forest Serv- has awarded a contract for the construction of secondary treat- ment plus sand filtration and chlorination fac- ilities. Contract awarded Jan. 1969. Est. completion date - Aug. 1969. Cost - \$45,000.
Knife River Administra- tion, Two Harbors (Lake Co.)	-	G	ST, DF	A	The Forest Serv- ice no longer utilizes these fac- ilities for other than storage.
Knife River Nursery Dwelling, Two Harbors (Lake Co.)	5 P - S G	G	ST, DF	A	

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MINNESOTA					
<u>Department of Agriculture - Forest Service - Superior National Forest, Cont'd.</u>					
White Pine Picnic Ground (Lake Co.) (3 P)	15 P - S	G	None	*	
Nine Mile Lake Campground (Lake Co.) (19 C)	95 P - S	G	None	*	
Norway Point Picnic Ground (St. Louis Co.) (6 P)	30 P - S	G	None	*	
White Face Reservoir Camp, Picnic Ground (St. Louis Co.) (59 C, 30 P)	445 P - S (10,000 gpd) (future)	G	None	B	* Plans call for the construction of a sewer system, aerated lagoon and spray irrigation systems with disinfection during FY 72. Est. Cost \$72,000.
Bird Lake Picnic Ground (St. Louis Co.) (3 P)	15 P - S	G	None	*	
Cadotte Lake Picnic Ground (St. Louis Co.) (27 P)	135 P - S	G	None	*	
Salo Lake Picnic Ground (St. Louis Co.) (3 P)	15 P - S	G	None	*	
Mesaba Dwelling (St. Louis Co.)	3 P - S	G	None	*	
Eveleth Nursery Administration and Nursery Eveleth (St. Louis Co.)	.8 S	G	Sec.	A	Package extended aeration plant and tile drain field
<u>U. S. Army (Corps of Engineers)</u>					
U. S. Vessel Yard Duluth (St. Louis Co.)	.2 S	G	ST, DF	A	Future plans call for connections to the municipal sewer system by FY 1970. Est. Cost - \$500.

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MINNESOTA					
U.S. Air Force					
Finland Air Force Station Finland (Lake Co.)	35.0 S	Surface drainage to Trib. of Baptism R. thence Lake Superior	ST, sand filter	B	40,000 gpd contact stabilization package sewage treatment plant with chlorination under construction; 30% completed; est. completion date May 1969
Duluth Air Force Missile Site Duluth (St. Louis Co.)	10.0 S	Roadside ditch	Sec.	C	Extended aeration package plant
Duluth Air National Guard Duluth (St. Louis Co.)	12.0 S	Miller's Creek	ST, DF	B	The Air Force has submitted a FY 69 project to connect their sewage disposal facilities to the Duluth Municipal sewer system. (Est. Cost \$170,000)
Department of the Interior - National Park Service					
Grand Portage Stockade Grand Portage (Cook Co.)	3.0 S	G	ST, DF	D	
Department of the Interior - Bureau of Indian Affairs					
MA Grand Portage Grand Portage (Cook Co.)	0.40 S	G	ST, DF	A	

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
MINNESOTA					
<u>Department of Justice</u> <u>Immigration and Naturalization</u> <u>Service</u>					
Border Patrol Station Grand Marais (Cook Co.)	2.0 S	Ground and Pigeon River	ST Built up sand filter	A	Recently completed the installation of new lift station, septic tanks and sand gravel filter, the effluent from which, if any, is chlorinated and discharged to the Pigeon River.
WISCONSIN					
<u>U. S. Coast Guard</u>					
Bayfield Station Bayfield (Bayfield Co.)	11 P - S	None	Incinerator type toilet	A	New facilities to be constructed with discharge to the Bayfield Municipal Sewer System. Scheduled completion date 1971. Est. Cost \$4,000.
Devils Island Light Station (Bayfield Co.)	5 P - S	G	ST, DF	A	
Superior Entry South Breakwater Light Station, Superior (Douglas Co.)	11 P - S	Allouez Bay	ST, DF	A	** 1973
<u>Department of Agriculture -</u> <u>Forest Service</u>					
<u>Chequamegon National Forest</u> (C - Campgrounds; P - Picnic Sites)					
Bad River Picnic Ground (Ashland Co.) (3 P)	15 P - S	G	None	*	

**STATUS OF WASTE WATER DISPOSAL AT FEDERAL INSTALLATIONS
LAKE SUPERIOR DRAINAGE BASIN**

(As of March 26, 1969)

(This inventory does not include installations connected to municipal sewer systems.)

Installation (Name & Location)	Volume & Type of Wastes (1,000 GPD)	Receiving Waters Drainage Basin	Treatment Provided	Rating	Remarks
WISCONSIN					
<u>Department of Agriculture - Forest Service</u>					
<u>Chequamegon National Forest</u> (C - Campgrounds; P - Picnic Sites)					
Beaver Lake Campground (Ashland Co.) (11 C)	55 P - S	G	None	*	
Lake Three Campground (Ashland Co.) (8 C)	40 P - S	G	None	*	
Potter Lake Picnic Ground (Ashland Co.) (2 P)	10 P - S	G	None	*	
Pigeon Lake Campground (Bayfield Co.)	2.0 S	G	None	*	
Two Lakes Campground (Bayfield Co.) (98 C)	13.0 S	G	None	B	A project has been submitted to provide a water- borne system with aerated lagoon, irrigation and disinfection. Cost estimate: FY 71 - \$20,000 design FY 72 - \$240,000 construction (Prelim. plans completed)
Drummond Lake Picnic Ground (Bayfield Co.) (6 P)	30 P - S	G	None	*	
Lake Owen Picnic Ground (Bayfield Co.) (18 P)	90 P - S	G	None	*	
Lake Owen Outlet Picnic Ground (Bayfield Co.) (4 P)	20 P - S	G	None	*	
Wanoka Lake Campground (Bayfield Co.) (20 C)	100 P - S	G	None	*	
Long Lake Picnic Ground (Bayfield Co.) (21 P)	105 P - S	G	None	*	

**STATUS OF WASTE TREATMENT AT FEDERAL INSTALLATIONS
LOCATED IN THE LAKE SUPERIOR DRAINAGE BASIN**

Installation Name & Location (Berth)	Compliment	Area of Operation	Treatment Provided	Rating	Remarks
<u>Vessels</u>					
<u>U. S. Coast Guard</u>	47	Lake Superior	None	D	Installation of adequate waste treatment facility is contingent upon development of suitable shipboard operational plant by the Coast Guard
USCGC Woodrush					
<u>National Park Service</u>					
M. V. Ranger III (165')	138	Lake Superior	Holding Tank	A	Discharges into the Houghton-Hancock Municipal Sanitary Sewer System. Depending on fund approval, eventual plans call for unloading into marine facilities at Isle Royale.
Tug J. E. Colombe (45 ft.)	2	Lake Superior	Holding Tank	A	"
M. V. Conrad L. (26 ft.)	2	Lake Superior	Holding Tank	A	"
M. V. Demray (26 ft.)	2	Lake Superior	Holding Tank	A	"
M. V. Louis J. (26 ft.)	2	Lake Superior	Holding Tank	A	"
M. V. C. M. Gothe (26 ft.)	2	Lake Superior	Holding Tank	A	"
<u>U. S. Army (Corps of Engineers)</u>					
Derrick Boat DK 20	5	Lake Superior	Macerator Chlorinator	B	Study is being conducted by Corps of Engineers to develop a suitable package aeration unit for this type of vessel.
Derrick Boat - Coleman	11	Lake Superior	"	B	"
Dredge - Gaillard	27	Lake Superior	"	B	"
Tow Boat - Marquette	8	Lake Superior	"	B	"
Tow Boat - Superior	9	Lake Superior	"	B	"
Tow Boat - Duluth	3	Lake Superior	"	B	"

APPENDIX B

LAKE SUPERIOR OPEN WATERS*
WATER QUALITY CRITERIA AND DESIGNATED USES
MICHIGAN, MINNESOTA, WISCONSIN

STATE	DESIGNATED USES	COLIFORM GROUP	DISSOLVED OXYGEN	SUSPENDED, COLLOIDAL, AND SETTLEABLE MATERIALS	FLOATING MATERIAL, RESIDUES, DEBRIS AND MATERIAL OF UNNATURAL ORIGIN	TOXIC AND DELETERIOUS SUBSTANCES
MICHIGAN	Domestic Water Supply Industrial Water Supply Recreation: - Whole Body Contact - Partial Body Contact Fish, Wildlife and Other Aquatic Life: - Intolerant Fish - Cold Water Species - Intolerant Fish - Warm Water Species Agricultural Commercial	The average of any series of 10 consecutive samples shall not exceed 1000 organisms per 100 ml nor shall 30% of samples exceed 5000/100 ml Fecal coliforms for the samples >100/100 ml	Cold Water Intolerant Species < 6 mg/l at any time Warm Water Intolerant Species Avg. Daily Value < 5 mg/l Any Single Value < 4 mg/l	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with designated use	No evidence of such material except of natural origin No visible film of oil or globules of grease	Conform to current USPHS Drinking Water Standards, except: Cyanide: > 0.2 mg/l Chromium: > 0.05 mg/l Phenols: Mo. Avg. > 0.002 mg/l Single Value > 0.005 mg/l Not to exceed 1/10 of the 96-hour TL ₅₀ obtained from continuous flow bioassays where the dilution water and toxicant are continuously renewed except that other application factors may be used in specific cases when justified on the basis of available evidence and approved by the appropriate agency
MINNESOTA	Domestic Consumption (1B) Fisheries and Recreation (2A) Industrial Consumption (3A)	> 50 MPN/100 ml	Oct-May < 7.0 mg/l Jun-Sep < 5.6 mg/l	Turbidity > 5.0 units No discharge from unnatural sources as to cause any nuisance conditions	Oil > Trace No discharge from unnatural sources as to cause any nuisance conditions	[> - mg/l] Arsenic 0.01 Barium 1.0 Cadmium 0.01 CCE 0.2 Chromium Trace Copper Trace Cyanide Trace Fluorides 1.5 Lead 0.05 Manganese 0.05 Nitrates 45.0 Selenium 0.01 Silver 0.05 Zinc 5.0
WISCONSIN	Public Water Supply Industrial and Cooling Water Commercial Shipping Recreation: - Whole Body Contact Beach areas Fish and Aquatic Life Trout Waste Assimilation	Arith. Avg. > 1000/100 ml Max. > 2500/100 ml during recreation season	< 80% Saturation nor < 5 mg/l at any time > 1 mg/l change	Substances that will cause objectionable deposits in the bed or on the shore of a body of water shall not be present in such amounts as to create a nuisance	Floating or submerged debris, oil, scum or other material shall not be present in such amounts as to create a nuisance	Substances in concentrations or combinations which are toxic or harmful to humans shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts, which by bioassay and other appropriate tests, indicate acute or chronic levels harmful to animal, plant or aquatic life

*Criteria and Uses as of March 1, 1969

> Greater Than > Not Greater Than

< Less Than < Not Less Than

Where designated uses have different criteria the most stringent criteria are listed.

TOTAL DISSOLVED SOLIDS	NUTRIENTS	TASTE AND ODOR PRODUCING SUBSTANCES	TEMPERATURE	pH	RADIOACTIVE MATERIALS
Total Dissolved Solids: } 500 mg/l Chlorides: Mo. Avg. } 50 mg/l	Nutrients originating from industrial, Municipal or domestic animal sources shall be limited to the extent necessary to prevent adverse effects on water treatment processes or the stimulation of growth of algae, weeds and slimes which are or may become injurious to the designated use	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use Phenols: Mo. Avg. } 0.005 mg/l Max. Concentration for a Single Value } 0.005 mg/l	Intolerant Fish Cold Water Species 70°F Maximum } 10°F Increase Intolerant Fish Warm Water Species 85°F Maximum } 15°F Increase when ambient temperature is less than 55°F } 10°F Increase when ambient temperature ranges from 56°F to natural maximum See Footnote Below¹	Range of 6.5 - 8.5 } 0.5 unit change within range	} 1000 pc/l of gross beta activity in absence of Sr-90 and alpha emitters If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposure above recommended limits established by the Federal Radiation Council
Total Dissolved Solids: } 500 mg/l Chlorides: } 50 mg/l Sulfates: } 250 mg/l Hardness: } 50 mg/l	No discharge from unnatural sources so as to cause any nuisance conditions	Threshold Odor: Number } 3 Phenols: } 0.001 mg/l	No Material Increase	Within range of 6.5 - 8.5	Gross beta concentration not to exceed 1000 pc/l in known absence of alpha emitters and Sr-90 Also: Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate authority having control over their use
Mo. Avg. } 500 mg/l Max. } 750 mg/l at any time	Materials producing color, odor, taste or unsightliness shall not be present in such amounts as to create a nuisance	Materials producing color, odor, taste or unsightliness shall not be present in such amounts as to create a nuisance	84°F Max. Change from natural unpolluted background } 5°F Rate of Change } 2°F/hour	Within range of 6.0 - 8.0 } 0.5 unit change if natural values are above 8.5 or below 6.5	Intake water supply will be such that by appropriate treatment and adequate safeguards it will meet PHS Drinking Water Standards, 1962

¹For the Great Lakes and connecting waters no heat load in sufficient quantity to create conditions which are or may become injurious to the public health, safety, or welfare; or which are or may become injurious to domestic, commercial, industrial, agricultural, recreational or other uses which are being or may be made of such waters; or which are or may become injurious to the value or utility of riparian lands; or which are or may become injurious to livestock, wild animals, birds, fish or aquatic life or the growth or propagation thereof.

APPENDIX C

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DISSOLVED OXYGEN

I. BIOLOGICAL EFFECTS. A continuous supply of oxygen is required for the normal metabolism of fish and most of their food organisms. Oxygen is used also in the respiration of plants and by bacteria. Oxygen enters the water chiefly by diffusion from the air and by the photosynthetic activity of plants. In general a balance is maintained between addition and removal, but because oxygen is not very soluble the water's capacity is small, so that any interference with the influx from the air or production by plants or any sudden increase in utilization (as, for example, in the bacterial oxidation of sewage wastes, etc.) soon lowers it to critical levels.

The oxygen concentration needed for maintenance varies widely with species, and there is evidence that highly desirable fish species in Lake Superior (coregonids, salmonids) require relatively high concentrations. There are indications, also, that several of the important food organisms (gammarids and shrimp) are even less tolerant of oxygen deficiencies. Within any one species the requirement varies with temperature, and especially with life-history stage, the eggs and early fry being more sensitive than the adults to oxygen lack. For such cold-water fish as salmonids a minimum of 6 mg/l has been recommended for good growth and general well-being of adults and their associated food organisms, and of 7 mg/l for eggs and fry.

II. SPECIAL CONSIDERATIONS. In addition to providing for growth, activity, reproduction and the like, the oxygen concentration must be high enough to protect against adverse conditions that may be encountered. For example, toxicants that enter through the gills become more toxic as the oxygen concentration is decreased, because the fish must pass more water over the gills to get enough oxygen, and this brings more toxicant against the gill surface. Because the low salt content of Lake Superior water permits such agents as heavy metals to be more toxic than they would be in harder water, it is especially important that the oxygen concentration be maintained high enough to counteract this hazard.

Little is known about the requirements of the adult stages of the important species of fish and food organisms under the environmental conditions of the bulk of Lake Superior, and even less about those of the more sensitive developmental stages. Further, little seems to be known about the oxygen concentration in various parts of the lake, especially at the bottom where the eggs and early stages of many species must live. Evidently the lake oxygen concentrations that have entered into maintaining the recorded levels at Duluth and Sault Ste. Marie so far have been high enough to maintain the aquatic population, and these should serve as guidelines until we have more information.

It is important to recognize that a reduction in oxygen from existing concentrations would serve as a warning of organic decomposition with subsequent release of poisonous materials such as hydrogen sulfide and ammonia.

III. EXISTING CONDITIONS. The gross range of dissolved oxygen concentrations over the period 1958-1968 was between 9.4 and 14.6 mg/l at Duluth, and 8.4 and 16.4 mg/l at Sault Ste. Marie, with means of 12.6 and 12.2 mg/l, respectively.

IV. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. The dissolved oxygen concentration of the open water of the lake shall not be less than 9 mg/l, at any time or any place in that habitat and 90% of the values should be greater than 10 mg/l. For habitats occupied primarily by warmer water fish (e.g., perch and walleye in the shallower bays) the criteria shall be not less than 5 mg/l at any time or place in that habitat.

V. REFERENCES.

1. Brinley, F.J. 1944. House Document 266, 78th Congress, 1st Session. Part II, Supplement F, Biological Studies, pp. 1275-1353.
2. Doudoroff, P. and C.E. Warren, 1962. Biological Problems in Water Pollution. Public Health Service; Third Seminar: pp. 145-155. Dissolved Oxygen Requirements of Fishes.
3. Ellis, M.M. 1937. Bulletin U.S. Bureau of Fisheries, Volume 48:365-437. Detection and Measurement of Stream Pollution.
4. Smith, L.L. et al, 1956. Sewage & Industrial Wastes 28:678-690. Aquatic Life Water Quality Criteria: Second Progress Report.
5. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C., April 1968.

TURBIDITY AND COLOR

I. BIOLOGICAL EFFECTS. Ecologically, the quality of the light, the intensity and the duration impinging on a given surface area controls the ecosystem through its influence on primary production. Light is the ultimate source of energy, without which life could not exist. Many structural and behavioral characteristics of organisms are directly influenced by light, therefore making it a vital factor as well as a limiting one at both the maximum and minimum levels.

Reduction of light presents a more serious problem in the aquatic environment than in the terrestrial. Light diminishes rapidly even in clear water, and changes in spectral composition and in other respects. Any extraneous material which is introduced to water, whether it be dissolved or suspended, will diminish the light intensity and possibly change the light quality. In short, suspended or dissolved solids absorb light energy, and this absorption will decrease that light energy available for primary production.

Production takes place in the water at a depth to which light penetrates so that in deep water lakes the light-penetrated "surface water" provides the major source of production for the entire depth. Effects of turbidity on desirable fish in Lake Superior would first appear as indirect ones on food supply.

II. CHEMICAL EFFECTS. Increases in turbidity require an increase in the available chlorine necessary for chlorination.¹ Further, an increase in turbidity makes phosphate and radioactivity removal harder to accomplish.² Turbidity produces in Lake Superior "colored water" which is not esthetically pleasing.³

III. SPECIAL CONSIDERATIONS. Since Lake Superior is deep (average depth about 600 feet) and cold (average temperature <42°F) primary production is already hindered. If light energy is removed because of turbidity or color, further stress would be placed on the lake's primary production. A combination of all these adverse conditions (extreme depth, low temperature, and light absorption) could render the lake practically sterile. Since the lake's depth cannot be controlled, and the cold temperature is required for the natural fish, it is most imperative that turbidity and color be removed from effluents being discharged into the lake.

IV. EXISTING CONDITIONS. Twenty-year averages of turbidity measurements taken daily at the Duluth Water Treatment Plant (Lakewood Pumping Station) show the mean turbidity of Lake Superior at this station to be about 0.3 JTU.

V. RECOMMENDED CRITERIA FOR LAKE SUPERIOR.

Turbidity: Less than 0.5 JTU (measured by dilution of standard solutions for JTU) for 90% of the time. Not to exceed 5.0 JTU as a maximum.

Color: Less than 0.010 absorbance units (10 cm path length) over wave length range 3500-8000 Å°, and less than 0.050 absorbance units (10 cm path length) over the wave length range 2400-3500 Å° for 90% of the time. Not to exceed five times these values as a maximum.

VI. REFERENCES.

1. Felsen, D. and Taras, M. J. Journal American Water Works Association, 42, 455 (1950).
2. Eliassen, R. et al. Journal American Water Works Association, 43 621 (1951).
3. Odum, E. P. Fundamentals of Ecology, p. 106. W. B. Saunders and Co., Philadelphia, 1959.
4. Clarke, G. L. Elements of Ecology, p. 185, John Wiley and Sons, Inc., New York. 1954.

TOTAL DISSOLVED SOLIDS

I. GENERAL CONSIDERATIONS. The quantity of dissolved solids by itself is not especially important in assessing water quality. More important are the kinds of dissolved solids that are present, and in some cases, the ratio of one to another. Only when the total exceeds many times the existing values in the lake, would there be any direct impairment.

Dissolved solids measurements do, however, provide a good index of the aging rate of the lake. Such correlations have been established in Lake Erie, as an example. For this reason, dissolved solids should be kept close to the present level to avoid undesirable aging effects.

II. EXISTING CONDITIONS. No data is available for St. Mary's River, but rarely is 60 mg/l reached at Duluth.

III. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. Ninety percent of the values should not exceed 65 mg/l.

IV. REFERENCES.

1. A Plan for Water Pollution Control - Lake Erie Report. U. S. Department of the Interior, Federal Water Pollution Control Administration, August 1968.

BACTERIA

I. GENERAL CONSIDERATIONS. The presence of bacteria in water was recognized early as an indicator of degraded water quality. The coliform bacterial count has been most widely used as an index of sewage contamination and possible accompanying hazard of human pathogens. Some waters have a high count even though there is little or no sewage contamination as coliform bacteria enter waterways from sources other than man, such as land runoff from agricultural lands.

The cold temperature, extreme water clarity (permitting deep penetration of sunlight) and sparsely populated watershed result in very low counts. The average total coliform value at Duluth is 3.68/100 ml and 7.81/100 ml at the St. Mary's River.

II. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. The maximum total coliform count should not exceed 1000/100 ml and 90% of the counts should be less than 10/100 ml at any location. The maximum fecal coliform count should not exceed 200/100 ml and 90% of the counts should be less than 10/100 ml at any location.

III. REFERENCES.

1. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C., April 1968.
2. Sanitary Significance of Fecal Coliforms in the Environment. U. S. Department of the Interior, Federal Water Pollution Control Administration, Publication WP-20-3.
3. The Bacteria, Volume II. Gunsalus and Stanier, Academic Press, 1961.
4. Pollutional Effects of Pulp and Paper Mill Wastes in Puget Sound. U. S. Department of the Interior, Federal Water Pollution Control Administration, March 1967.
5. Proceeding-Eleventh Conference on Great Lakes Research - 1968. International Association for Great Lakes Research.
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DETERGENTS (MBAS)

I. BIOLOGICAL EFFECTS. Detergents, because of their ubiquitous usage, are widespread in waterways. In 1965, the United States detergent manufacturers changed over from the "hard" tetrapropylene alkyl benzene surfactants. With present detergent formulations, the LAS surfactant is the primary toxic component and has been demonstrated to be two to four times more toxic than the old ABS compound. However, the removal of LAS by biodegradation is accompanied by a reduction in toxicity without the accumulation of toxic intermediates.

Most of the published detergent toxicity data for fish and other aquatic life is for old ABS formulations, while LAS toxicity information exists primarily for fish. Short-term studies by a number of investigators with LAS have shown that the lethal concentrations (96 hour TL_{50} values) for certain fish species range from 0.6 to 6.4 mg/l. A long-term study with fathead minnows indicated that the maximum acceptable concentration of LAS is 0.6 mg/l. Unpublished experiments of one to three months duration at the National Water Quality Laboratory have shown that the 30 day lethal value for smallmouth bass and northern pike fry is between 0.5 to 0.6 mg/l, and the threshold concentration of LAS for an amphipod and operculate snail is approximately 1.0 to 1.7 mg/l, and for a pulmonate snail greater than 2.0 mg/l.

II. SPECIAL CONSIDERATIONS. The methylene blue method is used for quantitatively measuring surfactants, but does not differentiate between the now existing levels of ABS and LAS occurring in natural waters or certain natural substances. Therefore, it has been proposed and generally accepted that these anionic substances be reported as methylene blue active substances (MBAS).

The Public Health Service Drinking Water Standards, 1962, limits ABS in drinking water to 0.5 mg/l since higher concentrations may cause undesirable tastes and foaming. A similar LAS standard has not yet been adopted. An important secondary effect related to a detergent standard is that polyphosphates comprise a large percentage of powdered detergent formulations and furnish nutrients to receiving waters, and may promote nuisance conditions (e.g. algal blooms).

III. EXISTING CONDITIONS. Available information on surfactant concentrations in Lake Superior indicates a range from 0.01 - 0.05 mg/l.

IV. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. The maximum concentration for Lake Superior should be 0.4 mg/l MBAS and 90% of the measurements less than 0.1 mg/l MBAS at any single location.

V. REFERENCES.

1. Thatcher, Thomas O., and Joseph F. Santner, 1966. Acute Toxicity of LAS to Various Fish Species. Proceedings 21st Purdue Industrial Waste Conference, Engineering Extension Series No. 121., 50(2): 996-1002.
2. Pickering, Quentin H. 1966. Acute Toxicity of Alkyl Benzene Sulfonate to the Eggs of the Fathead Minnow, *Pimephales promelas*. Air and Water Pollution Journal, 10: 385-391.
3. Pickering, Quentin H. and Thomas O. Thatcher. 1968. The Chronic Toxicity of Linear Alkylate Sulfonates to the Fathead Minnow (*Pimephales promelas*, Raf.). Submitted to Journal Water Pollution Control Federation for publication.
4. Swisher, R. D., J. T. O'Rourke, and H. D. Tomlinson. 1964. Fish Bioassays of Linear Alkylate Sulfonates (LAS) and Intermediate Biodegradation Products. Journal of American Oil Chemical Society, 41: 746-752.
5. Marchetti, R. 1965. Critical Review of the Effects of Synthetic Detergents on Aquatic Life. Stud. Rev. Gen. Fish. Coun. Medit., No. 26, 32 pp.

Donald I. Mount

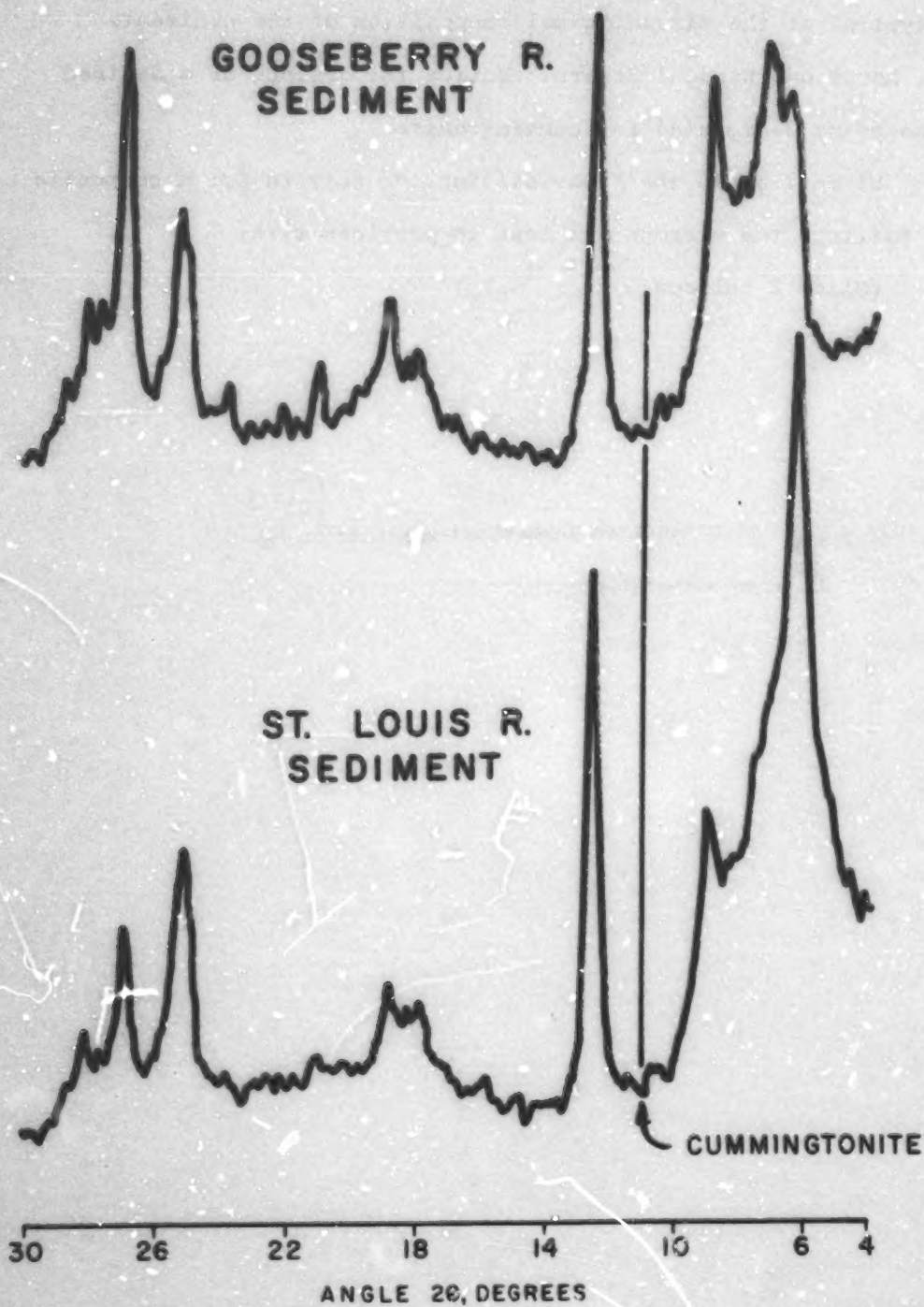
Mr. Chairman, I will presently use five slides, Slides 1, 2, 4, and 5 are included in the back of the printed material that I have given you, and I would request, if possible, that Slide 3 be made an exhibit to the conference.

Utilizing the described technique of tracing tailings, their distribution was determined. Detailed examination of the bottom sediments and water samples in 13 tributary streams to Lake Superior failed to reveal more than a trace of any of the amphiboles in this 2 micron size fraction. A trace was found in a single sample from the Nemadji River. The northeasternmost stream sampled was a creek entering the lake near Grand Portage, Minnesota. Cummingtonite was absent in this stream, as well as in the following rivers: Devil's Track, Temperance, Baptism, Beaver, Gooseberry, Stewart, French, Lester, and the St. Louis, as well as two streams in Wisconsin, the Nemadji and the Brule. The absence of cummingtonite in the fine sediment fractions of these tributary streams ranging from the Canadian border to Duluth indicates that the contribution of cummingtonite in the watershed of concern is minimal.

Slide 1 shows typical X-ray diffraction patterns of the clay minerals that are found in the natural stream sediments of the Minnesota and Wisconsin tributaries.

(Slide 1 follows:)

SLIDE 1



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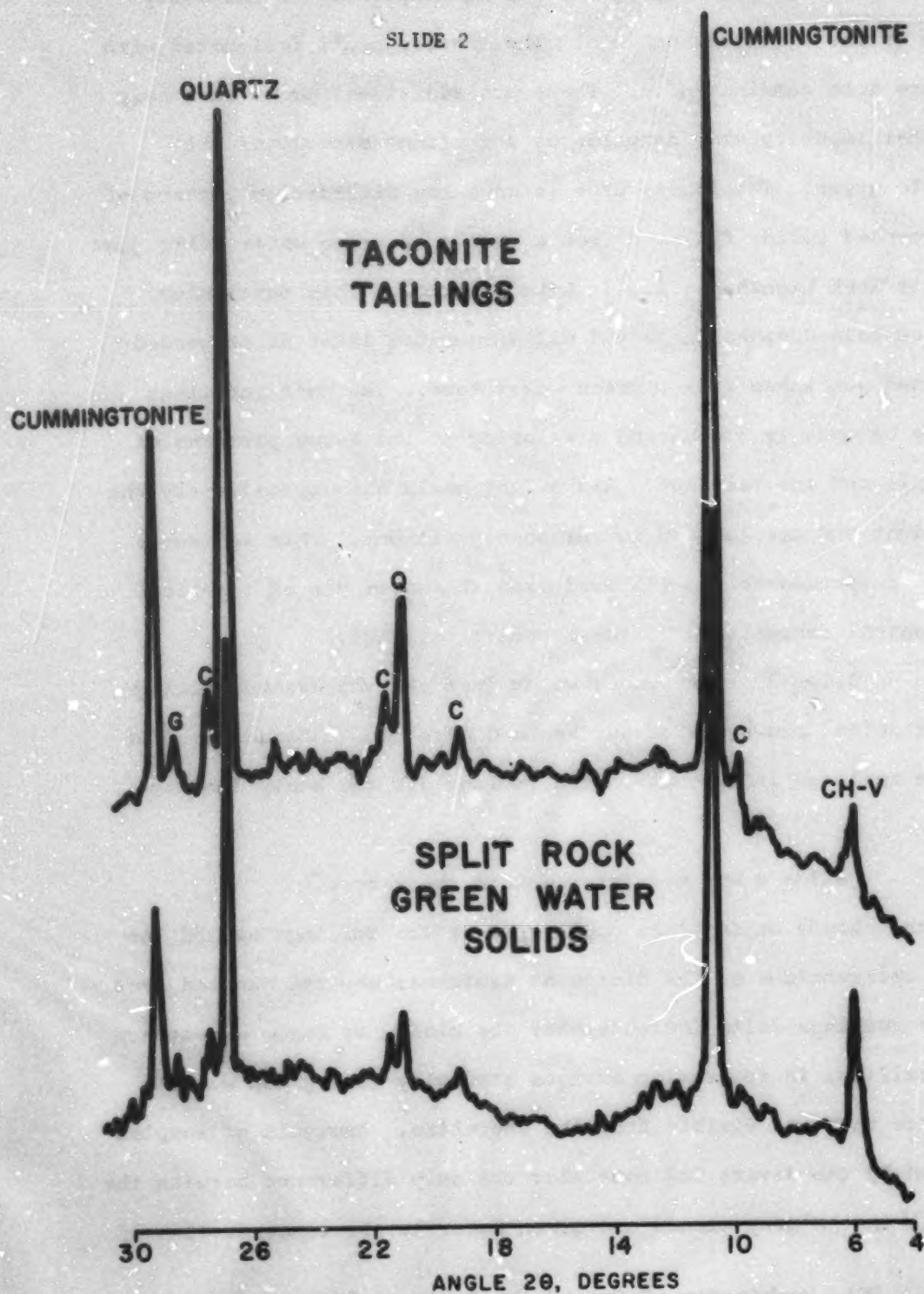
The upper, or Gooseberry River pattern, is typical of the sediments of the North Shore tributaries. The pattern at the bottom of the slide is typical of the mineralogical composition of the sediments of the St. Louis and Nemadji Rivers. Notice the absence of a defined peak at the point designated for cummingtonite.

Slide 2 shows the X-ray diffraction pattern for a composite sample of tailings two microns and less in particle size.

(Slide 2 follows:)



SLIDE 2



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Note the two large peaks designated as cummingtonite in the X-ray pattern of the taconite tailings. The smaller peaks designated with a "C" are also cummingtonite. These are additional peaks that help to further identify cummingtonite as a distinct mineral of the amphibole group. The lower curve is an X-ray diffraction pattern of the suspended solids filtered from a sample of green water taken just off Split Rock Lighthouse Bay in Lake Superior. This particular sample contained approximately 3 milligrams per liter of suspended solids and was taken from a green water mass. The most important point to be made is the strong similarity of the X-ray patterns of the sample and the tailings. All of the peaks are approximately the same height and are located in the same positions. This indicates that the suspended solids filtered from the water are of identical mineralogical composition to the taconite tailings.

Slide 3, taken under water just off the Reserve Mining effluent delta, shows one of our scuba divers near a dense cloud of taconite tailings in suspension and peeling off the heavy density current.

(Slide 3 was not entered into the record.*)

Notice the cloudy or fog-like appearance of the tailings around the diver. Observations of the divers at distances several hundred feet from the tailings delta indicate that the cloudy or foggy appearance of the tailings in suspension changes gradually to a green water appearance that was visible from the shoreline. Analysis of samples collected by the divers indicate that the only difference between the materials in the grey clouds and green water is the concentration of

*On file FWPCA, Washington, D.C. and the Regional Office, Chicago, Illinois.

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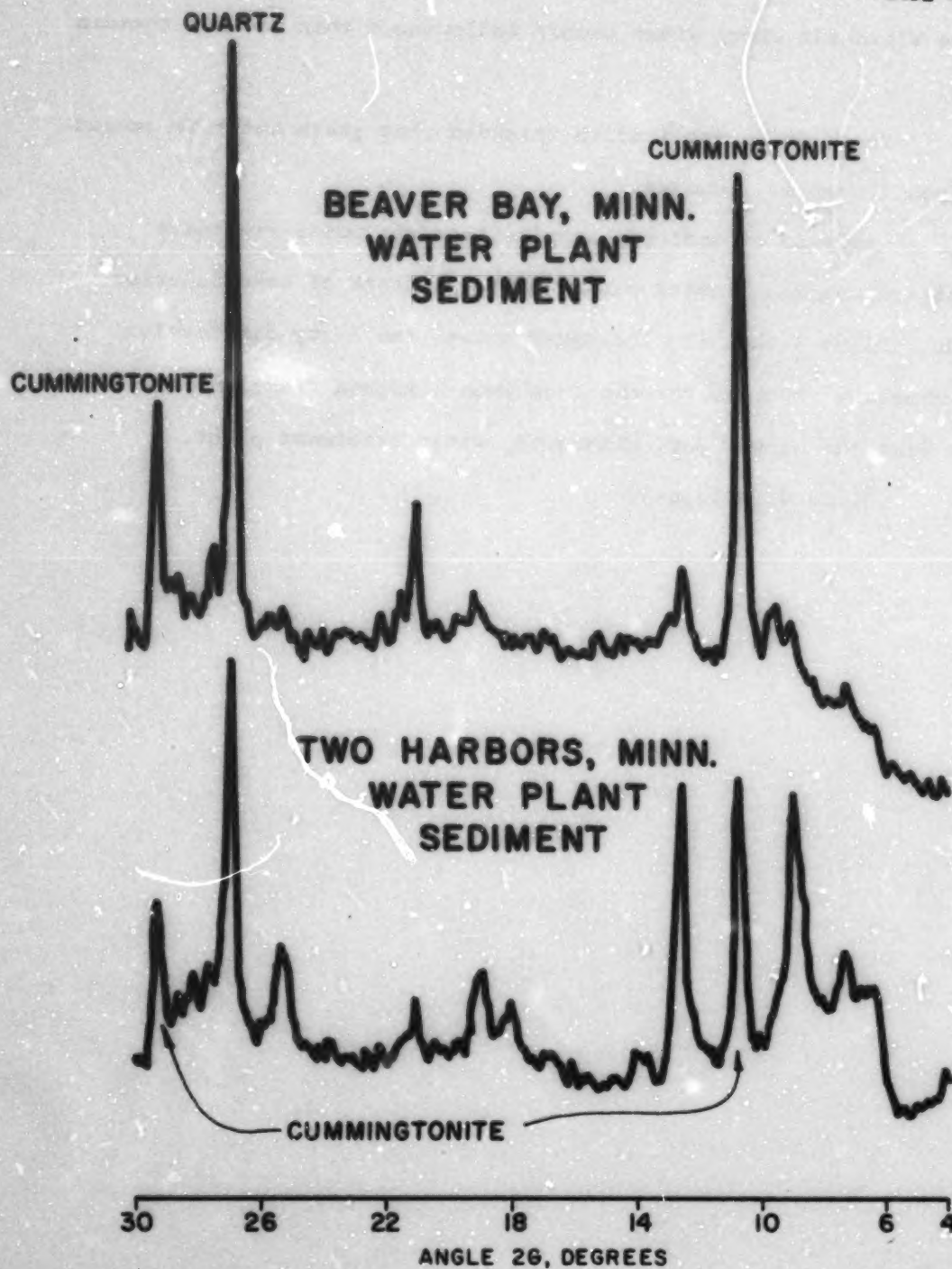
the suspended solids. Mineralogically these solids are identical to the fine fractions of the tailings. Samples of green water collected along the Wisconsin shore after runoff following a rain did not contain tailings.

There is no implication intended that green water is caused by tailings. Some is, however.

Analysis of sediment samples from the water treatment plants of communities located along the North Shore of Lake Superior were made. Slide 4 shows, in the upper curve, the X-ray diffraction pattern that was obtained for the less than 2 micron fraction of the sediment from the Beaver Bay, Minnesota, water treatment plant.

(Slide 4 follows:)

SLIDE 4

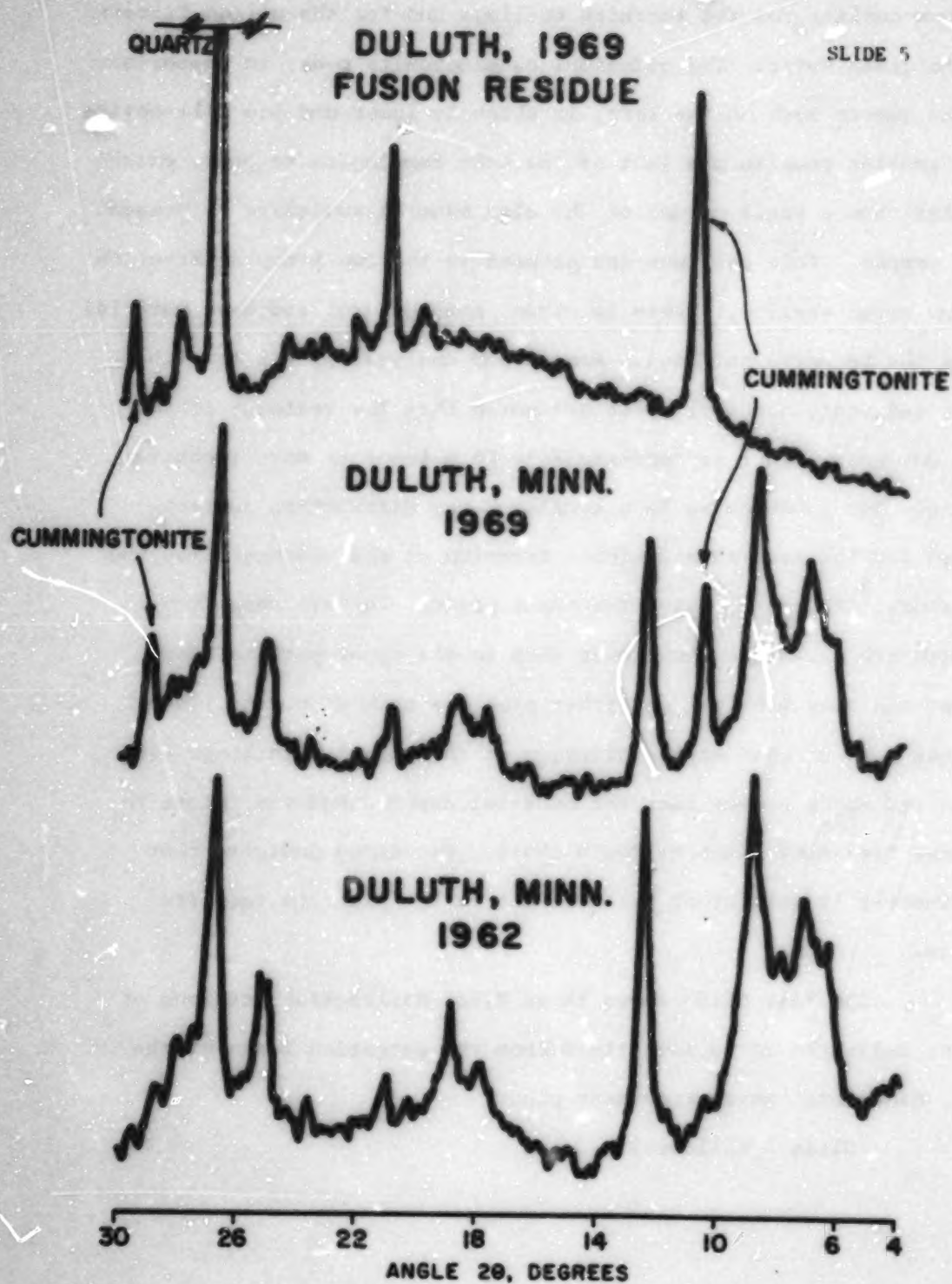


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In this X-ray diffraction pattern there is a strong similarity to the one shown earlier for the taconite tailings and for the solids filtered from the green water. The principal cummingtonite peak, in comparison with the quartz peak on the left, is slightly lower and you will notice also a smaller peak to the left of the main cummingtonite peak, which indicates that a small amount of the clay mineral kaolinite is present in the sample. This peak was not present in the two X-ray diffraction patterns shown earlier. There is, then, some natural sediment material besides the taconite tailings. From X-ray analyses of all fractions of this sediment, however, it is estimated that the sediment in the Beaver Bay water plant is approximately 85 percent or more taconite tailings. The lower curve is a similar X-ray diffraction pattern obtained for the less than 2 micron fraction of the sediment from the Two Harbors, Minnesota, water treatment plant. In this case, the cummingtonite peaks are much lower than in the upper pattern, and peaks of the clay minerals on either side are much stronger. Thus, there has been a considerable dilution of the taconite tailings with natural sediments by the time the material has reached the intake to the water treatment plant at Two Harbors. Estimates indicate that approximately 15 percent of the sediment in the plant is taconite tailings.

The last slide shows three X-ray diffraction patterns of sediment collected at various times from the detention basin of the Duluth, Minnesota, water treatment plant.

(Slide 5 follows:)



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The lower curve is from the sediment collected in 1962. In this case there is a complete absence of a cummingtonite peak. In the center curve, from a sample collected in April 1969, you will notice a cummingtonite peak which is slightly less than the peak at the Two Harbors water plant. Notice also the change in abundance of clay minerals in this particular sample. We estimate that the sediment in the Duluth plant contains approximately 7 to 9 percent taconite tailings.

In order to verify our identification and to further strengthen the quantitative results obtained on the 1969 Duluth, Minnesota, sample shown in the center curve, we have carried out some additional chemical tests on this particular sample. The results of these tests are shown in the upper curve. For this X-ray pattern, all of the clay minerals have been removed by a chemical treatment developed in our laboratory, leaving only the residue of quartz and cummingtonite (the principal minerals found in the taconite tailings)--in the small size fraction, I should add. This greatly simplifies the quantitative estimates of the minerals that are present since only cummingtonite and quartz are left in the residue and we are dealing with a 2-mineral mixture rather than a 4 or 5. Since the weight of the residue is known, an upper limit is placed on the percentage of the original sample that is composed of tailings.

Additional X-ray analyses were made of sediments from the water plant at Grant Marais, Minnesota, and from the water detention tank at the Grand Portage National Monument at Grand Portage. A trace (less than 1 percent) of taconite tailings was found in sediment from the Grant Marais plant, but none was found at Grand Portage.

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In addition to the sediment samples that have been collected from the various water treatment plants along the North Shore, we have also used X-ray diffraction for the analysis of sediment samples collected from toilet flush tanks in private homes in Grand Portage, Grand Marais, Beaver Bay, Two Harbors, and Duluth. In all cases the sediments collected from the toilet flush tanks had similar X-ray diffraction patterns to those found in the sediments collected in the detention basins of the various water treatment plants. A sediment sample from a flush tank in Proctor (served by the Duluth water system) produced a pattern similar to that obtained from the sediment in the Duluth water plant. This home is over 15 miles away from the Duluth Water Treatment Plant.

In summary, tailings were found in the water supplies of Grand Marais, Beaver Bay, Two Harbors, and Duluth. They were absent in a sediment sample taken in the Duluth water plant. Tailings constituted a larger percent of the suspended solids in the plants closest to the Reserve discharge.

Tailings were also prominent in "green water" samples collected along the North Shore and apparently cause the green appearance at certain times. Not all green water is caused by tailings. And green water caused by runoff from the Wisconsin shore did not contain tailings during late 1968.

(Applause.)

MR. DOMINICK: Thank you, Dr. Mount, for a very excellent report.

Do we have any questions?

Charles R. Collier

MR. FURDY: Dr. Mount, were any collections taken and analyzed on any water other than Minnesota waters?

DR. MOUNT: We have gathered a great deal of data and have done many experiments since the taconite study group began in March of 1968. We are concluding in our report at this time the results that we feel that we can stand on.

MR. FURDY: You are only reporting on results from Minnesota waters at the present time?

DR. MOUNT: The results I gave here without exception are from Minnesota, with the exception of the Brule and Nemadji.

MR. FURDY: Thank you.

MR. DOMINICK: Are there any other questions?

Mr. Charles Collier, who is the District Chief of the U. S. Geological Survey of St. Paul will comment on Conclusions 1 and 2 presented on Page 27 of the report.

Mr. Collier.

(Applause.)

STATEMENT OF CHARLES R. COLLIER,
DISTRICT CHIEF, U. S. GEOLOGICAL
SURVEY, U. S. DEPARTMENT OF THE INTERIOR,
ST. PAUL, MINNESOTA

MR. COLLIER: Mr. Chairman and conferees:

The Water Resources Division, U. S. Geological Survey,
U. S. Department of the Interior, welcomes the opportunity to

Charles R. Collier

participate in this conference. The Geological Survey has responsibility for the collection of basic data on the water resources of the Nation and for the analysis and interpretation of these data for use by others in the conservation, development, and management of the resource. We are, therefore, extremely interested in this conference and in the conclusions or actions which may result.

Before discussing sedimentation in Lake Superior and its tributaries, I would like to make available to the conference the following four tables of water quality analyses. These chemical analyses, for the Pigeon, Baptism, Beaver Bay, and St. Louis Rivers in Minnesota, were obtained during the summer of 1968 and are not yet published in the annual series, Water Resources Data for Minnesota.

(The four tables of water quality analyses follows:)

STANDARD TREATMENT TO LAKE SUPERIOR
 4-0105, Pigeon River, at Middle Falls, near Grand Portage, Minnesota
 Chemical analyses, in mg/l

Date of collection	Nitrate charge (mM)	Silicon (SiO ₂)	Alumina (Al ₂ O ₃)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Phosphate (PO ₄)	Bromine (Br)	Calcium activity (mM at 25°C)	Alk as CaCO ₃	Non-carb. anion (mM)	Temp. (°C)	Color	pH	Total dissolved solids (mg)	Residual solids (mg)	Calc. Residual Solids (mg)	
April 3, 1968	514	5.3	0.6	0.30	0.06	7.2	2.5	1.2	2.4	28	0	14	6.2	1.1	0.1	0.35	0.03	23	5	1	58	7.0	28	55	44
April 25, 1968	1,830	5.7	.9	.89	.00	7.2	2.3	1.2	1.2	23	0	12	8.5	0.6	.2	.05	.13	19	0	1	55	6.6	27	65	41
May 8, 1968	993	4.4	.8	.18	.00	7.8	2.4	1.4	0.6	29	0	14	6.5	0.6	.1	.02	.04	24	5	10	40	6.8	29	51	40
June 6, 1968	2,402	6.1	1.0	.31	.00	9.0	3.1	1.4	1.4	33	0	16	8.5	0.5	.1	.06	.05	27	8	15	100	6.7	35	78	49
July 10, 1968	647	5.0	3.3	.16	.00	9.3	2.6	1.6	0.3	35	0	17	7.0	1.6	.1	.04	.00	29	5	17	25	7.0	34	54	49
Aug. 31, 1968	397	8.4	0.9	.27	.00	12	3.6	3.0	1.0	48	0	26	7.7	1.8	.5	.04	.03	30	5	15	50	7.2	44	70	63

MINOR ELEMENTS

Date of collection	Copper (Cu) (mg)	Zinc (Zn) (mg)	Total Chromium (Cr) (mg)	Cadmium (Cd) (mg)	Lead (Pb) (mg)	Mercury (Hg) (mg)	Lithium (Li) (mg)	Strontium (Sr) (mg)	Cobalt (Co) (mg)	Arsenic (As) (mg)
June 6, 1968	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0	--
July 10, 1968	.00	.00	.00							0.01
Aug. 31, 1968	.11	.00	.00							.00

PROSPECT TRENCH TO LAKE JOHNSON
 4-01141-00 Indian River near Beaver Bay, Minnesota
 Chemical analyses, in mg/l

Date of collection	Mo- nium (ppm)	Alu- minum (100g)	Iron (%)	Man- gan- ese (ppm)	Cal- cium (%)	Mg- nesium (%)	So- dium (%)	Pot- as- sium (%)	Li- thium (ppm)	Car- bon- ate (%)	Alk- ali (%)	Cal- cium (%)	Fluo- ride (%)	El- ectro- lyte (%)	Or- tho- phos- phate (%)	Bar- ium (%)	Con- ductivity at 25°C	Alk- ali (%)	Bar- ium (%)	Temp- (°C)	Col- or	pH	Total dissolved solids	Col- or	Alk- ali (%)
Oct. 11, 1967	106	9.6	0.7	0.38	9.4	3.1	2.5	0.4	28	0	16	8.5	0.3	0.8	0.25	0.08	16	16	1	3	90	7.3	36	94	
April 3, 1968	188	7.8	0.5	0.20	6.2	1.9	1.7	1.8	21	0	10	8.0	0.2	1.3	0.25	0.08	37	17	6	1	60	6.9	23	66	
April 8, 1968	508	7.0	0.0	0.25	5.8	1.8	1.3	0.7	13	0	6	10	0.3	2.0	0.11	0.08	53	10	12	1	60	6.4	21	50	
May 7, 1968	594	6.1	0.8	0.20	6.5	2.0	1.7	0.4	20	0	10	9.0	0.2	1.0	0.00	0.03	56	16	8	8	75	7.0	24	57	
June 3, 1968	397	6.5	0.0	0.25	7.0	2.2	1.7	0.4	22	0	11	10	0.2	1.1	0.10	0.03	57	18	9	17	60	6.6	26	65	
July 11, 1968	51	6.7	0.8	0.20	11	3.4	2.8	0.3	41	0	20	9.2	0.4	1.0	0.08	0.07	89	33	7	20	70	7.1	40	77	
Aug. 11, 1968	15	6.4	1.2	0.20	15	4.3	2.6	1.0	64	0	38	6.7	1.7	1.4	0.03	0.04	114	53	1	15	40	7.2	38	92	

Date of collection	Trace elements					Heavy metals			Organic		
	Copper (%)	Lead (%)	Vanadium (%)	Chromium (%)	Barium (%)	Lead (%)	Mercury (ppm)	Strontium (ppm)	Cobalt (ppm)	Arsenic (ppm)	Antimony (ppm)
June 3, 1968	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00
July 11, 1968	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00
Aug. 11, 1968	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00

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best available copy.

Year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	2908	2909	2910	2911	2912	2913	2914	2915	2916	2917	2918	2919	2920	2921	2922	2923	2924	2925	2926	2927	2928	2929	2930	2931	2932	2933	2934	2935	2936	2937	2938	2939	2940	2941	2942	2943	2944	2945	2946	2947	2948	2949	2950	2951	2952	2953	2954	2955	2956	2957	2958	2959	2960	2961	2962	2963	2964	2965	2966	2967	2968	2969	2970	2971	2972	2973	2974	2975	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The chemical characteristics of these four streams are similar and are probably representative of the water quality of many of the streams along the north shore of Lake Superior. Of the several minor elements analyzed, small concentrations of copper, zinc, strontium, and arsenic were found in some samples.

Sediment, the product of the natural processes of weathering and erosion of the rock and soil of a watershed, is transported into Lake Superior by its many tributary streams. Erosion and transport of this sediment is influenced to some degree by changes in land use, vegetative cover of the soil, construction in the basin, and by other cultural improvements. Sedimentation is, however, a natural process and cannot be completely eliminated.

Although the sediment yield of each tributary to Lake Superior has not been measured, past investigations have provided data sufficient for estimates of the general magnitude of the sediment yields and have delineated problem areas.

The average annual sediment yield of the Pigeon, Baptism, Beaver Bay, and St. Louis River Basins in Minnesota was estimated to range from 5.6 to 17 tons per square mile and average about 10 tons per square mile per year throughout the total drainage area of these basins¹. This yield is of the same magnitude as that for basins in the Superior Uplands physiographic province reported in Appendix G, Fluvial Sediment, Upper Mississippi River Comprehensive Basin Study, and may also be representative of the yield from the many Canadian streams along the north shore of Lake Superior.

¹Collier, C. R., 1968, Preliminary report on streamflow conditions and sedimentation in the vicinity of Silver Bay, Minnesota, U. S. Geological Survey, November 1968.

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In the Upper Peninsula of Michigan the reported annual sediment yields for the East Branch Escanaba and Michigamme River Basins were 2-1/2 to 3 tons per square mile or less². Because of similar physiographic setting, and from less frequent measurements on streams tributary to Lake Superior, it is reasonable that most of the Lake Superior Basin in Michigan would have sediment yields of similar magnitude.

Along the south shore of Lake Superior the Wisconsin streams have considerably higher sediment yields. Limited data on the Bad River near Odanah, for example, indicate a long term average yield of about 270 tons per square mile. One of the most severely eroded and high sediment-producing areas in the Lake Superior Basin is the red clay area in northwestern Wisconsin. Sediment discharge data of streams draining this area are not available at this time. The problem has been recognized by interested State and Federal agencies, and is now under investigation³.

Compared to yields in other areas of the country, the sediment yields of streams tributary to Lake Superior are generally very low. In the agricultural areas of the Missouri and Ohio River Basins, for example, average annual sediment yields of streams are seldom less than 100 tons per square mile and some streams have sediment yields in excess of 1,000 tons per square mile.

² R. F. Flint, 1967, in U. S. Geological Survey Water-Supply Paper 1842, "Water resources of the Marquette Iron Range area, Michigan", by S. W. Wiitala and others.

³ Erosion and sedimentation control on the red clay soils of northwestern Wisconsin, Red Clay Interagency Committee, 1967.

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The largest single source of solid material entering Lake Superior along the Minnesota shore is the taconite processing plant at Silver Bay. The plant, operated since 1955 by Reserve Mining Company, now discharges about 62,000 long tons of waste material per day to Lake Superior. These tailings are discharged from the plant in a thin slurry through flumes or "launders" and onto a delta formed by the tailings. From the end of the launders the water and tailings material flows over the surface of the delta in continuously shifting and meandering streams to the edge of the delta and into Lake Superior. Reserve Mining Company has reported that about 45 percent of the tailings remain on the delta and about 55 percent are carried into Lake Superior.

The particle-size distributions of the taconite tailings were determined by the visual accumulation tube and pipette methods of analysis. These analyses are based upon the fall velocities of spherical particles through quiescent water by application of Stokes' law, and closely reflect the effective particle size of the material in water. The resulting particle-size distributions are determined as sedimentation diameters, defined as the diameter of a sphere that has the same specific gravity and has the same terminal uniform settling velocity as the given particle in the same sedimentation fluid⁴.

Although it is recognized that sediment particles are not spherical in shape and shape does affect the fall velocities of

⁴Report No. 12, Some fundamentals of particle size analysis, Interagency Committee on Water Resources. Subcommittee on Sedimentation, December 1957 Government Printing Office.

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particles, the diameters obtained by these hydraulic methods are the accepted parameters of study of the small sediment particle. Sedimentation diameters are a function of the settling rates and are of more importance than the actual diameters. Stokes' law expresses the terminal fall velocity of a sphere whose fall is dependent only upon the viscous effects of the fluid. It is valid throughout the range of particle sizes between those large enough to have drag resistance and those so small that they remain in colloidal suspension. It is applicable for the size of particles which are apt to be transported into Lake Superior beyond the face of the tailings delta.

Stokes' law considers density and diameter of the particle, density of the fluid, acceleration due to gravity, and the dynamic (absolute) viscosity of the fluid. It is expressed as:

$$v = \frac{2}{9} \frac{(\rho_1 - \rho_2) g r^2}{u}$$

where v = velocity of fall in cm/sec

ρ_1 = density of sphere in gm/cm³

ρ_2 = density of fluid in gm/cm³

g = acceleration due to gravity (981 cm/sec/sec)

r = radius of sphere in cm

u = dynamic viscosity of the fluid in dyne-sec/cm²

The terminal fall velocities of individual particles of various sizes of taconite tailings were computed using a specific gravity of 3.00 for the tailings, and a water temperature of 40 degrees Fahrenheit, about 4 degrees centigrade, as representative of the temperature of Lake Superior. The velocities were:

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<u>Particle Diameter (millimeter)</u>	<u>Terminal Fall Velocity (cm/sec)</u>	<u>Terminal Fall Velocity (ft/hr)</u>
0.062	0.259	30.6
0.016	0.0172	2.04
0.004	0.00108	0.127

The particle-size distribution of the total tailings determined from a single sample supplied by Reserve Mining Company was 56 percent sand (2.0 to 0.062 millimeters diameter), 39 percent silt (0.062 to 0.004 millimeters), and 5 percent clay (less than 0.004 millimeters), Figure 1.

(Figure 1 follows:)

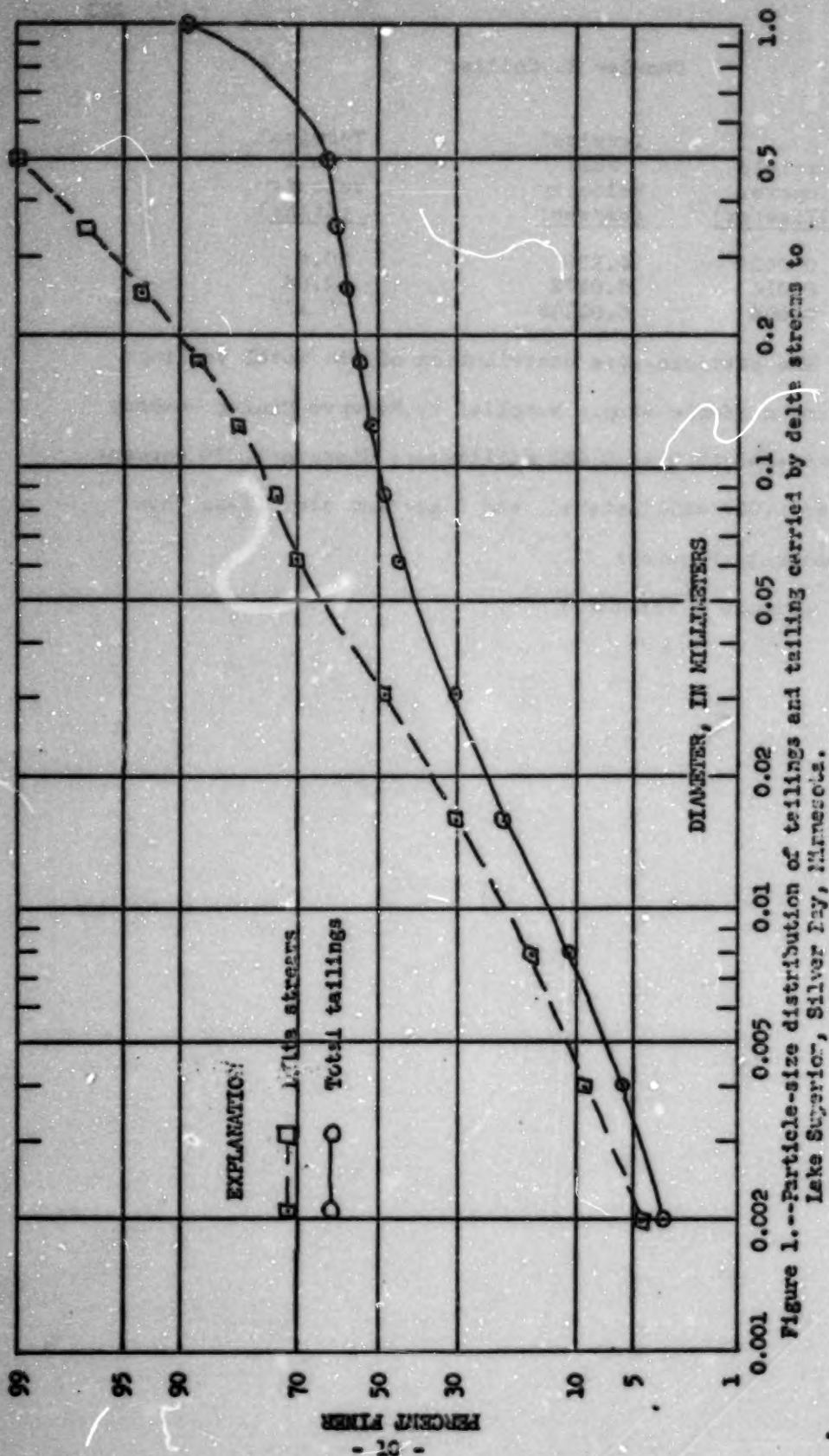


Figure 1.--Particle-size distribution of tailings and tailing carried by delta streams to Lake Superior, Silver Bay, Minnesota.

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These results agree closely, particularly for the smaller sizes, with the analysis reported by Reserve Mining Company. Near the edge of the delta, the particle size distribution of the tailings in transport by the streams on the delta was 30 percent sand, 61 percent silt, and 9 percent clay. The difference in these analyses indicate that more of the sand and larger silt-sized particles are deposited on the face of the delta.

The water, containing a heavy concentration of fine tailings, flows into the lake along the face of the delta. Because of the high concentration of fine tailings, a density current is formed which flows downward along the face of the delta. The tailings particles do not settle at their respective settling velocities but are carried downward by the density current. The extent and duration of this current is not known. The material does not spread over the surface of the lake but sinks rapidly from sight within a few feet from the edge of the delta.

However, some of the material has been observed to break away from the density current by the action of local lake currents, and form what appears to be clouds of fine tailings. As the material in these clouds is gradually dispersed and the concentration of particles is decreased, the individual particles will assume their fall velocities and begin settling to the bottom. The fall velocities of the small particles are extremely slow and the lake currents described earlier this morning are sufficient to carry the particles for long distances before they are deposited on the lakebed.

Sampling and chemical analysis of the lakebed sediment by Reserve Mining Company have indicated a thin layer of tailings deposited

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over a wide area south and southwest of the delta. Core sampling of the deposits in the lake have been collected and the percentages of tailings in the mixture of tailings and natural sediments were determined by an analysis for titanium content.

The extent and location of the tailings deposit on the lakebed is shown in the map in Figure 2.

(Figure 2 follows:)

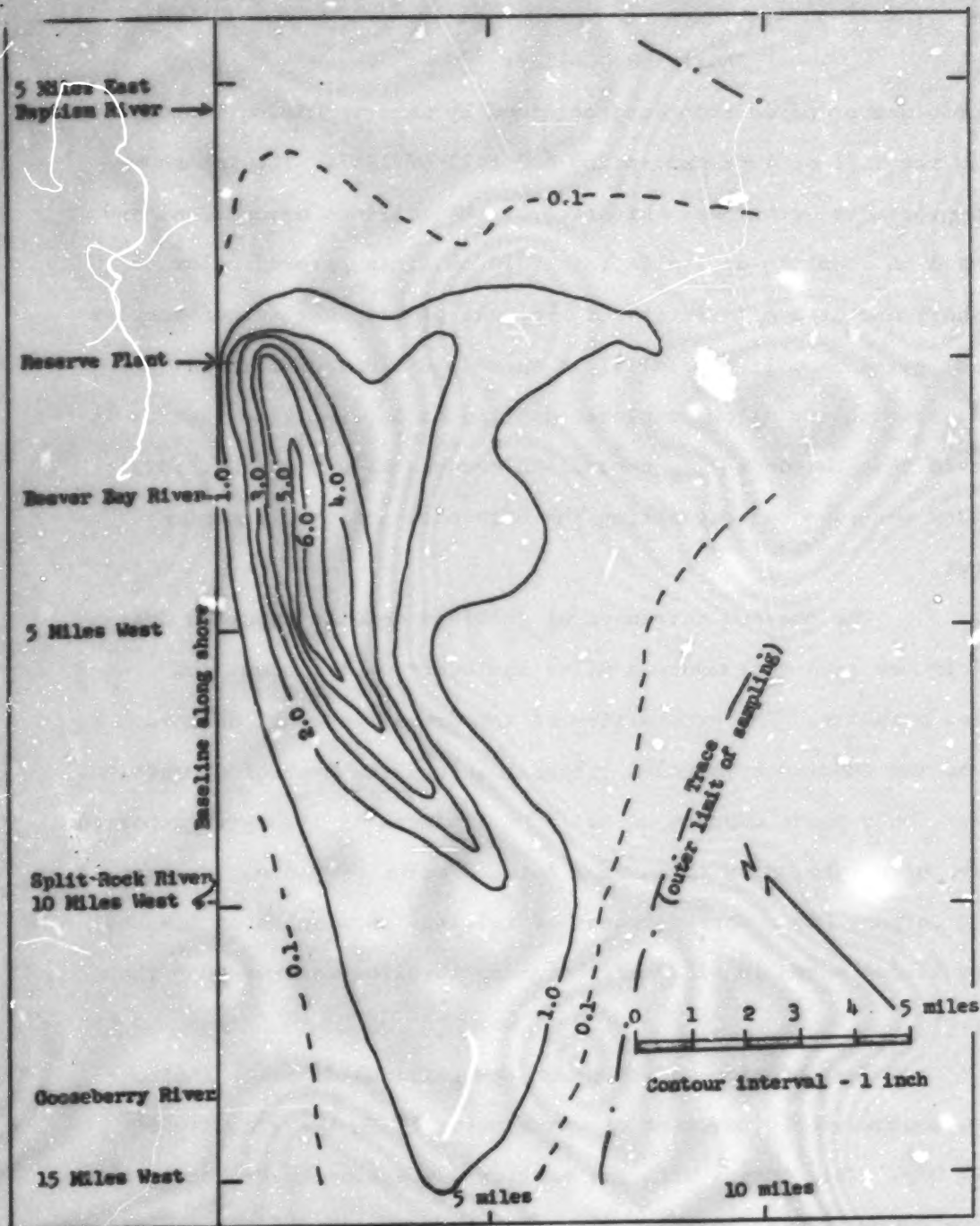


Figure 2. -- Map showing the approximate deposition of taconite tailings in Lake Superior.

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This map was prepared from data obtained by Reserve Mining Company during the fall of 1966 and spring and fall of 1967. The map shows the approximate extent and thickness of the tailings deposition, and is based on sampling at 1 mile intervals on lines perpendicular to the shore and at 5 mile intervals from the plant. One set of samples was collected on a line parallel to shore and 5 miles offshore. Conditions did not allow complete sampling at any one time, but it is believed that the amount of deposition changes slowly so that little accuracy was lost by compositing the data obtained over a 1-year period.

The maximum thickness of tailings deposit reported was 6-3/4 inches in a core taken 5 miles southwest of the plant and 2 miles offshore. The extremities of the deposit are not defined. None of the samplings extended offshore beyond the area of deposition. However, only trace amounts of tailings 1/6 inch or less were reported in several of the cores taken from 7 to 10 miles offshore. Reserve Mining Company has reported traces of tailings in samples of lakebed sediments collected 10 miles offshore and 15 miles southwest of the delta.

The location and shape of the tailings deposits indicate that a southwesterly movement of water prevails in the vicinity of Silver Bay. This agrees with the earlier discussion by Dr. Baumgartner on lake currents and indicates also that the direction of the prevailing local currents at depth do not differ greatly from the direction of the surface currents.

The characteristics, behavior, and deposition of the taconite tailings in Lake Superior are not fully documented at this time.

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Questions concerning the extent and duration of the density currents on the face of the delta, the characteristics and behavior of the natural sediment and tailings particles, definition of the lake currents in the vicinity of Silver Bay and western Lake Superior, and the extent of deposition of the tailings must be answered to understand fully the effect of the tailings on the water resource.

Thank you.

(Applause.)

MR. DOMINICK: Thank you, Mr. Collier.

Do we have any questions?

Mr. Purdy?

MR. PURDY: No.

MR. DOMINICK: Thank you.

Mr. Clifford Risley, who is Director of the Lake Michigan office and who was also in charge of the studies conducted in Lake Superior prior to this year, will comment on the Federal Water Pollution Control Administration's findings of the Lake Superior water quality studies included on Pages 27 and 28.

Mr. Risley.

(Applause.)

STATEMENT OF CLIFFORD RISLEY, JR.,
DIRECTOR, LAKE MICHIGAN BASIN OFFICE,
FEDERAL WATER POLLUTION CONTROL
ADMINISTRATION, DULUTH, MINNESOTA

MR. RISLEY: I am Clifford Risley, Jr., Director of the Lake Michigan Basin Office of the Federal Water Pollution Control

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Administration. The Lake Michigan Basin Office has made several studies of the lake to locate sources of pollution and to determine the areas affected by pollution.

The first study in 1966, and the second in 1967 were conducted in order to assess the effects of lake water movements on the dispersion of pollutants throughout Lake Superior. Dr. Baumgartner has already told you what we learned about lake currents from these studies. I will, therefore, limit my discussion to some of the most significant physical and chemical findings.

Seven lake stations were sampled in 1966 and 22 stations were sampled in 1967. These stations were each sampled at 3 feet below the surface and at mid-depth and at 8 inches above the bottom. This gave a total of 87 lake samples.

During the 1966 study two high values for copper were found, one with a value of 0.037 mg/l near the north shore of the lake in the vicinity of the French River, and one with a value of 0.036 mg/l on the south shore near Port Wing, Wisconsin. Both of these stations were located in the western tip of Lake Superior. Copper was not detected in any of the other samples.

During the 1967 study a copper concentration of 0.113 mg/l was measured in one sample found northeast of the Apostle Islands. Copper was undetected at the other stations.

Total phosphorus concentrations ranged from 0.010 to 0.011 mg/l in 1966 and from 0.003 to 0.010 mg/l in 1967. The highest value was observed near Port Wing, Wisconsin, but other moderately high values were encountered in all stations of the west tip of the

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lake as well as at a few scattered points throughout the lake.

Lead concentrations higher than 0.05 mg/l and zinc concentrations higher than 0.03 mg/l were also found in a few samples at scattered locations in the lake in the 1967 study.

Results of all other parameters tested were found to be below those criteria usually cited for protection of aquatic life.

In response to a request from the U. S. Army Corps of Engineers for comments on revalidation of the Corps's permit to Reserve Mining Company, several agencies of the U. S. Department of Interior reported a continuing concern over the deposition of taconite tailings into Lake Superior. In response to these concerns an Interior study group was formed to investigate the effects of the taconite tailings in Lake Superior. The Corps of Engineers and state agencies of Minnesota and Wisconsin provided information and acted as observers in the study group.

1967 PRELIMINARY STUDIES

The initial observations of the Reserve Mining Company's plant at Silver Bay were made by the Federal Water Pollution Control Administration during a routine reconnaissance in May of 1967.

Waste material conveyed by a flume from the plant to the lake shore had formed a large delta. Large particles had deposited near the end of the flume and lighter solids and suspended materials carried over the delta to the lake.

SILVER BAY STUDY

In September 1967 water samples were collected at 7 points extending up to 7 miles from the delta.

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Chemical analysis of these samples revealed concentrations of copper and zinc in excess of levels considered as necessary for the protection of aquatic life.

Secchi disc readings at most of the stations indicated that suspended material reduced the light penetration into the water of the affected part of the lake.

In view of these findings, further investigation of this problem was indicated.

1968 IN-PLANT SURVEY

In May 1968 an in-plant survey of Reserve Mining Company's process wastes was conducted by both the Bureau of Mines and Federal Water Pollution Control Agency to determine the waste load being discharged to Lake Superior.

Some of the results of the in-plant survey are presented as "Conclusion 10" on Page 28 of the report titled "An Appraisal of Water Pollution in the Lake Superior Basin," which was distributed today.

The U. S. Geological Survey determined the particle size distribution of the tailings and reported that 4 percent of the material was less than 2 microns in diameter. Since 60,000 tons of waste are discharged daily, calculations indicate that 4 percent or 2,400 tons of this discharge are less than 2 microns. This material would not be heavy enough to settle but may stay suspended in the water indefinitely.

STUDY OF LAKE AREA INFLUENCED BY RESERVE MINING COMPANY DISCHARGE

Federal Water Pollution Control Administration personnel aboard the Bureau of Commercial Fisheries vessel SISCOWET made a

Study in June and July of 1968. Water samples and a few bottom sediment samples were collected at 33 sampling stations covering about 30 square miles of Lake Superior adjacent to the Reserve Mining Company at Silver Bay. Water samples were collected at 3 feet below the surface, at mid-depth, and at 8 inches above the bottom. A total of nearly 200 water samples were analyzed.

BIOLOGICAL RESULTS

Although the number of bottom samples were limited, it should be noted that benthic organisms were found in only 4 of the 9 stations sampled in the waste disposal area. Pollution-sensitive scuds were not found in the waste disposal area. Each sample collected outside the waste area contained a number of benthic organisms, and scuds were found in each of these samples.

CHEMISTRY RESULTS

High iron concentrations were found over the major part of the sample area near the lake bottom with the highest value in proximity to the company property. The iron values increased from the surface to the bottom and were 7 to 9 times higher than the highest value in the rest of the lake. Soluble iron was found to be about the same as total iron in surface and mid-depth samples and 1/4 the total iron near the bottom.

Lead values exceeded 0.05 mg/l in several locations. Some lead values higher than this level were recorded at scattered locations in the open lake.

Copper exceeded 0.008 mg/l, the level normally accepted for the protection of aquatic life, in a large area starting south of the discharge and extending 3 miles southward into the lake.

A sample of water collected at a point 100 feet deep and 100 feet off-shore from the Reserve discharge contained 0.11⁶ mg/l of

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copper. After filtration through 0.45 micron membrane filter, the sample contained 0.051 mg/l of copper, a sufficient concentration to produce a toxic effect on sensitive organisms. Bioassays did not indicate such acute effects, however, and additional checks were made to determine the reason. Subsequent filtration through a 0.1 micron filter left 0.036 mg/l of copper.

Apparently some of the particulate copper is not biologically active in a bioassay of short duration. The hazard due to copper shifting from biologically inactive to active copper was not determined.

The criterion commonly accepted for zinc, based on protection of aquatic life, is 0.03 mg/l. This value was exceeded at several sampling points in the surface and mid-depth samples, but no high values were observed in the bottom water samples. These results were 3 times higher than were found anywhere else in the lake. The soluble zinc was about 1/3 the total zinc values at the points tested.

At several stations total cadmium and soluble cadmium values equaled or exceeded 0.002 mg/l, the criteria level accepted for protection of aquatic life. Cadmium was not detected in the rest of the lake.

One-tenth of a milligram per liter (mg/l) is a level of nickel commonly accepted for the protection of aquatic life. There were two stations where this level of total-nickel was exceeded in the surface samples and two stations where this value was exceeded in the bottom samples.

Total-chromium values up to 0.037 mg/l were found in the Reserve Mining Company study area. This is 10 times the value cited

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as a trace amount. No chromium was indicated in the 1966 or 1967 lake survey samples.

Phosphorus concentrations found in the near bottom were about 5 to 10 times higher than those observed in the lake in 1967. Suspended solids exceeded the values normal to the major portion of the lake. Suspended solids and phosphorus both increased from top to bottom.

Turbidity values also increased from top to bottom. The values near the bottom were 10 to 60 times higher than at the surface and from 2 to 40 times higher than those observed in the major portion of the lake. Highest values occurred in the vicinity of the Reserve Mining Company and extended southward.

In summary, the findings of these studies show that most of Lake Superior has water of high quality with the exception of phosphorus, which was high at all stations in the west tip of the lake and at scattered points throughout the rest of the lake, and with the exception of copper and lead values, which were also high at several scattered points in the lake.

The studies of the Reserve Mining Company discharge and a 30 square-mile lake area adjacent to the discharge area show that 60,000 tons of taconite waste solids are discharged daily from the Reserve Mining Company directly into Lake Superior. Twenty-four hundred tons per day of these waste solids are less than 2 microns in diameter, a particle size which will stay suspended in water for a considerable time after discharge.

The investigations in the vicinity of Silver Bay revealed lead, copper, zinc, cadmium, and nickel levels in concentrations in

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excess of commonly accepted levels for protecting aquatic life. Iron concentrations in the area affected by Reserve Mining Company discharges increased from surface to bottom and were 9 times higher than those observed in the open waters of the lake. Suspended solids and turbidity measurements were observed to be relatively high in the vicinity of the Reserve Mining discharge, forming a pattern to the south and southwest of the discharge. The bottom water turbidity values were from 2 to 40 times higher than those found in the rest of the lake in 1967 lake-wide survey.

Water transparency measured by Secchi disc reading was 4.5 meters in the area influenced by the waste discharge and 12 meters in the lake beyond that area, which indicates that the turbidity of the discharge reduces the light penetration in the area involved.

In conclusion, the study area selected for sampling was too small to define the area adversely affected. Analysis of data by the study group indicated that the area affected extended beyond the furthest sampling point.

Thank you.

(Applause.)

MR. DOMINICK: Thank you.

Do we have any questions here?

MR. PURDY: Do we have time for questions?

MR. DOMINICK: Yes, Mr. Purdy.

MR. PURDY: Mr. Risley, earlier today Mr. Kimball indicated the possibility of on-land disposal of the tailings. But yet in your presentation on Page 4, commencing with: some "2,400 tons of this discharge are less than 2 microns (in size and that) this material may

stay suspended in the water indefinitely," from this would you reach the conclusion that even if you had on-land disposal and overflow basins that this 2400 tons per day would still reach the lake?

MR. RISLEY: I think a large portion of it would if you had overflow disposal. I think what would be best would be if we would recirculate this.

MR. FURDY: O.K. Thank you.

MR. BADALICH: Mr. Risley, I have a question. In this presentation of yours this afternoon you refer to a study of the 1968 report. I believe this report was available in the preliminary conference, but certainly not in the bibliography at this time. Is there any reason for it being withdrawn?

MR. RISLEY: The report made by our agency should have been in the bibliography. If it is not there, it is an oversight.

MR. BADALICH: So you are basing your conclusions on a report that has not been available to the conferees?

MR. RISLEY: The report was given to all members of the taconite study group, which included two of the conferees, the three conferees, the Federal conferees. But we did not do it with the State Commissioners because they were not represented, and went to all Department agencies and the Corps of Engineers. This was an unpublished report, but was available to all study members.

MR. BADALICH: Mr. Chairman, I think if we are going to consider the results of this presentation we should have the validity or the report at our disposal so we could certainly look into the foundation for some of these conclusions.

MR. DOMINICK: We would be happy to provide the conferees with the FWPCA contribution to that. Is it the 1967 report you are concerned with at this point?

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MR. BADALICH: No, Mr. Chairman, this is the 1968 report. I believe it would be in reference to Page 4, June and July 1968, where some 200 water samples were analyzed.

MR. DOMINICK: Do you have that report available, Mr. Risley?

MR. RISLEY: I have a couple of copies along. The information is available, as is all data which we collected. There is always an open file.

MR. DOMINICK: Fine.

We would be happy to make that available.

MR. BADALICH: I have another question. The reference is made on Page 6 here to the level being in excess of the criteria level accepted for protection over aquatic life. You also refer to, on another level, Page No. 7 where lead, copper, zinc, cadmium, and nickel levels in concentrations in excess of commonly accepted levels for protecting aquatic life. I believe, in looking at the water quality standards that we have listed on Pages 82 and 83, it is my understanding these are water quality standards for Lake Superior for the accepted States. Is this another set of standards or what you have here for water aquatic life?

MR. RISLEY: These were referred to because there were no numbers assigned to the criteria for Lake Superior in the State standards for these particular parameters, and the criteria cited, there were some numbers assigned for protection of drinking water quality. These standards, or those that are in the water quality criteria, are recommended to the Federal Water Pollution Control Administration for the protection of aquatic life.

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MR. SADALICH: Mr. Chairman, in the Minnesota standards I believe you indicate the levels of concentration for many base metals, including arsenic, barium, cadmium, CCE, chromium, copper, cyanide, fluorides, lead, manganese, etc., I believe we have about 15 listed here. But I wonder if you would agree with the standards.

MR. DOMINICK: Fine.

In response to your first question, it has been brought to my attention on Page 52 of the Public Report No. 49 we do list there the "Investigation of the Distribution of Taconite Tailings in Lake Superior, U. S. Department of the Interior, Federal Water Pollution Control Administration, Great Lakes Region, September-October 1968."

Is that the report you have used in presenting this statement, Mr. Risley? I have No. 49 on Page 52.

MR. RISLEY: I am not certain whether all the chemical data that I have talked about here today is in that report. That title is slightly different than the title which I used on the report when published.

MR. DOMINICK: Very well.

We will certainly make this available to the conferees.

Are there any further questions?

Thank you.

Dr. Mount, we would like to call upon you again to discuss Appendix C of the report.

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STATEMENT OF DR. DONALD I. MOUNT,
DIRECTOR, NATIONAL WATER QUALITY
LABORATORY, FEDERAL WATER POLLUTION
CONTROL ADMINISTRATION, DULUTH,
MINNESOTA

DR. MOUNT: Mr. Chairman and conferees:

The following comments that I have prepared are a rather cursory treatment of the recommended order of quality criteria for standards that you find listed in table form on Page 44 and individually with explanations in Appendix C that you indicated.

The National Water Quality Laboratory was asked by the Great Lakes Region to develop a set of specific water quality criteria that would: 1) maintain the present appearance of the lake, 2) protect present aquatic life, 3) protect the high quality drinking water supply, and 4) prevent slow long-term aging, deterioration, of the lake. To do this, the existing quality of the lake had to be considered as well as the permissible limits as related to water use. In most cases there seems to be a reasonable difference between existing levels and those that would limit the present use. For this reason massive treatment costs would not be required to meet these limits.

The small amount of data available for the lake might cause one to wonder how the existing conditions can be established for the various parameters as shown in Appendix C. There are several features rather unique to Lake Superior that make this possible, even though most of the data came from only two stations. While not

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necessarily in order of importance, the following characteristics make this possible:

1. Tributaries to the lake are small and have localized effects only.
2. Pollutant discharges to the lake are small in most cases and are located far apart so that zones of influence in the lake are usually small and well-separated.
3. The lake does not stratify thermally to a significant extent so that mixing top to bottom occurs often.
4. Lake currents are well-developed and mix the waters continuously.
5. One sampling station is located at the head of the lake in a prevailing current pattern and one at the outlet of the lake representative of the opposite end.

The former station, the one at the head of the lake, is at the Duluth water plant and many of the analyses we used were made by the Duluth Water Department.

6. The large volume of the lake makes rapid changes very unlikely except in shallow shore areas.

The pitfalls of "zero" tolerances or "not detectable" limits that have been used by such agencies as the U. S. Food and Drug Administration have been very troublesome because as analytical sensitivity increases, the minimum amount detectable increases also. Such changes are frustrating for regulatory agencies and costly for those who must comply, because the standard changes with each new method of analysis. Other statements, such as "no material addition

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of heat," are nebulous and could be construed to prohibit discharge of secondary effluent from sewage treatment plants, depending on how "material" is defined. In these criteria the words recommended in Appendix C "trace" and "no material addition," etc., have been replaced by numbers in order to definitely establish the limit in clearly understandable terms.

The importance of the slow flushing rate and the presence of persistent potential pollutants is recognized. Should this lake be contaminated by persistent pollutants, the use of this lake for several generations may be jeopardized. The aquatic life in the lake is probably as sensitive to heat, oxygen, and metals as any biota in the United States and is further affected by the very soft water in which many pollutants, especially metals, are most toxic. For this reason concentrations found elsewhere to permit aquatic life are not acceptable in Lake Superior. There is no implication that aquatic life will be killed immediately should these concentrations recommended in Appendix C be slightly exceeded, but essential processes, such as reproduction or food production, will be impaired.

Certain of the recommended standards are designed to maintain the present appearance of the lake. These are color, turbidity, temperature, methylene blue active substances (foam producers), and phosphorus. It seems obvious that the appearance of this lake is of great importance to the tourist business and that blue color, water clarity, and absence of visible algae are desired.

These slides are for showing purposes. They are not to be included in the record.

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MR. DOMINICK: Are the conferees doing as Dr. Mount has described?

DR. MOUNT: Slide I shows the Lester River entering Lake Superior during the 1969 snow melting period. The turbidity of the river when this picture was taken was 25 JTU. This turbidity is 50 percent of the limit for aquatic life as recommended by the National Technical Advisory Commission. You can see how inappropriate this condition would be for the whole lake.

Slide II shows "green" water along the Minnesota shore in the autumn of 1968. The suspended solids content of 12 green water samples was 1.9 mg/l as compared to .5 mg/l for 7 blue water samples. The visibility of an object placed below the surface (Secchi Disc) was 24 to 30 feet in the blue water and 4 to 8 feet in the green water. An increase of approximately 1.4 mg/l 5.5. reduce light penetration by approximately 20 feet, but this change would not be discernible in most of the Nation's waters where turbidity is much higher.

Another group of standards is recommended primarily for the protection of the aquatic life -- principally lake trout, lake herring, and white fish -- presently inhabiting the lake. These are copper, lead, zinc, cadmium, nickel, cyanide, hydrogen sulfide, temperature, pH, methylene blue active substances, color, and complex waste.

One of these, zinc, appears to be much closer to an unsafe concentration in the lake than any of the others. Experimental work recently completed and properly corrected for the water type suggests that concentrations now occurring at the lower end of the

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lake are high enough to reduce reproductive success of trout.

Slide III shows a view of a perch that has been exposed to copper at 40 ppb (.04 mg/l) for 8 weeks in Lake Superior water and a control fish. You can see the exposed fish is very thin and apparently ready to die. Similar tests on trout show that newly hatched ones have greatly reduced growth rates at 15 ppb, .015 mg/l copper, and important food organisms die at 10 to 12 ppb.

Hydrogen sulfide is currently being intensively studied through an FWPCA research grant at the University of Minnesota. Tests have shown that 8 ppb (.008 mg/l) is lethal to fish eggs. The standard recommended in Appendix C is expressed as total sulfide and has been appropriately increased to 20 ppb to allow for slightly less than 50 percent that would be dissociated at a pH of 6.8. Furthermore, since all important fish species deposit their eggs on the bottom and have long incubation periods, measurement of standards compliance is recommended at the place where eggs occur to make the standard ecologically significant.

Several standards are recommended primarily for use in monitoring the lake's aging. Total dissolved solids is closely related to the aging of Lakes Erie and Michigan and provides an easily measured index. Ammonia, dissolved oxygen, and bacteria are excellent predictors of organic matter decomposition and changes would signal development of undesirable conditions. A drop in D.O. from present concentrations to 6 to 7 ppm would be accompanied by the production of vast quantities of undesirable decomposition products such as ammonia, nitrate, and potentially hydrogen sulfide and methane,

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depending on the conditions. Such situations appear remote now but the same feeling was expressed about Lake Erie less than 25 years ago.

I have given rather cursory treatment to the individual parameters and many are important in more than one group of the four groups mentioned. I attempted to mention each parameter under the group where it is most restrictive.

I shall be happy to answer specific questions the conferees may want to ask, but I may have to rely on my staff for specific details in some cases.

(Applause.)

MR. DOMINICK: Thank you, Dr. Mount.

Do we have any questions from the conferees?

MR. BADALICH: Mr. Chairman, I think we will defer questions until tomorrow morning.

MR. DOMINICK: Very fine.

Mr. Vogt?

MR. FRANGOS: Mr. Chairman, I have a short question.

On Page 4 there is a discussion of zinc. Could the doctor comment on what the source of this zinc might be?

DR. MOUNT: I should have mentioned that the data that was used for the present or in giving the existing conditions to Lake Superior, I believe that is usually Item No. 3 or 4 in Appendix C, came principally from two of the national network monitoring stations which have been in operation since approximately 1958. We received the entire computer printout for all data, and in both recommending

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the recommended standards as well as the existing conditions we looked very carefully at the extremes that we found and the existing conditions as they were, including the means. We had quarterly means, minimums and annual means and finally a maximum and minimum for the station for all years of record. Some of the means work which were used in the temperature and pH conditions. And we feel that for the open part of the lake the conditions presented here are reasonably accurate.

I can say that in comparing the two stations, the one in the St. Mary's River and the one at the Duluth water plant, there were differences between the two but no consistent ones. In some cases I remember particularly iron was much lower at Duluth than St. Mary's. On the other hand, zinc was much lower--did I say that right, yes--zinc, was much lower here at Duluth and much higher at St. Mary's. It seems to me that copper was reversed. But the point I am trying to make is that you could not say all parameters were of lower quality or toxic materials were of higher concentration at one than the other.

MR. VOGT: Mr. Chairman, I think you were focusing attention on some or at least on one of the questions that we had which was: Just what do these proposed values mean or how do they relate to present values for each of these parameters, and would you say that generally the present parameters, the values are higher or lower, or did you make a general statement?

DR. MOUNT: No. As I said or meant to say if I didn't in my introductory remarks, we feel that in almost every case the open lake values are low to much lower -- if lower is the proper word. In

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the case of oxygen it would be higher. But I guess I should say the quality is high so much higher than these existing recommended standards. If you would care to compare on a parameter-by-parameter basis, if you have looked at Appendix C, we have given a section on what the extremes and means, etc. are. Just below that you will see the standards that we have recommended.

I would like to underline that in some cases, and there is one that I single out, not because of any known source but simply because the values are high at the lower end of the lake, high in terms of what we believe we know about the chronic effects of zinc. This is a very interesting, I shouldn't say interesting, a very baffling metal because, as you know, it is an essential metal. It is reasonably soluble and not very toxic on an acute or short-term basis. However, in chronic testing that we did while I was still in Cincinnati we found that one could reduce the zinc concentration perhaps by a factor of two or three below the 96-hour value. This is the concentration that kills half of the test animals in 96 hours. If you would reduce it six or sometimes below that value, the fish would be much better and the fish look happier, if fish can look happy, and yet these fish were totally unable to reproduce and spawn.

This is the kind of information that has gone into the recommended standards that we have given you here. We have tried to tell you and give you in the first part under "Biological Effect" our thinking and our evidence that we have used in preparing this. For example, in the case of chromium, we were not able to come up with good data in the time that we had from the literature in regard to

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toxicity of chromium. But I think we know in this case that diatoms and green algae are much more sensitive to chromium than are the fishes that we are concerned with here on the lake. However -- I don't believe I have that in front of me; thank you -- the upper limit that we have recommended for chromium is .05 parts per million. That would be 50 parts per billion, and this is based strictly on drinking water limits as recommended by the National Technical Advisory Committee and, I believe, the Public Health Service as well. However, you will notice that we suggested that 90 percent of the time it should be less than that. I feel we can cut back on the standards to give ourselves a little bit of margin of safety to protect us against other situations, for example zinc, where we feel we have already stretched our limit on the standards that we have recommended. We believe the zinc standards, as recommended, will result in about a 10 percent reduction in the reproduction success of the trout. We reason this way: these levels are there and we can probably tolerate some reduction in egg production in these species because most of them lay more eggs than would be required.

I am long-winded here, but I am trying to show you that we have thought about these things.

MR. VOGT: I think that is an extremely important point, Mr. Chairman. And in looking at Appendix C here, for existing conditions, often an average value is quoted and I am looking specifically right now at phenols on Page 91. On the other hand, the recommended criteria are the maximum values. So it seems to me if we are going to be able to make a judgment -- I am not saying that we should make

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a judgment on these -- but if a judgment is determined to be necessary in the conclusions, it would seem to me we would have to have the range of values for each parameter rather than averages or means which, in some instances, are the only values that we have for the existing conditions.

DR. MOUNT: May I comment on that?

MR. DOMINICK: Yes, go ahead, Dr. Mount.

DR. MOUNT: We ran into somewhat of a snag with phenols. First of all, I believe that it mentions -- and let me be sure -- you notice it says that the "data from Duluth and St. Mary's River indicate that total aromatics (including phenols) average less than 0.001 mg/l." This means that phenols were only one portion of the materials that would be included under the measurement of total aromatics. Phenols are considerably less than the 0.001 mg/l now. It is true in this case we do not have a range in it. Why do we recommend 0.001 mg/l on phenols? The simple reason is, after talking with Mr. Rosen of Cincinnati -- and the other man's name slips me at the moment -- you can't be technical with any degree of confidence. You will see on Page 44 we just have not given a value for 90 percent of the time and have only suggested a maximum, and this is principally because of the problem of determining phenol at these levels.

Also, may I point out, if you just look across at the other page, you will see that we do give the range for existing conditions in regard to detergents. We gave the range before we had them.

MR. VOGT: The same thing prevails in phosphorus. I haven't had the opportunity to review these, but in phosphorus you

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give the average concentration, too. Now, there may be more, I just don't know. I haven't had an opportunity to look at them.

Then the other question is, these values, of course, are recommended criteria for open waters. What is shoreline water? I note that you have in your indication here a method of calculating a tributary influence and a mixing zone, but now if there isn't a tributary and we have shoreline water and high turbidity merely from runoff, is this classified as open water?

DR. MOUNT: I think I will have to say simply, we have recognized there is a terrible problem in deciding what is shore water and what is open water. We have concluded there would be an even worse problem if we tried to define what was shore and open water, so we didn't say anything. We did say the corner that appears for defining the zone of influence at the mouth of the tributary might be useful to you in thinking about the different discharges of the tributary. It has the advantage when the flow of the tributary increases the area of influence increased as well.

We pondered a number of zones of influences using this zone formula, from some of the largest to some of the smaller ones. We found, particularly in the case of Duluth where we had a lot of information from the water plant as well as other measurements on this end of the lake, we found that this formula provided about the right boundary as the river flow changed based on any experience of the influence the river has on the lake, not in every case but in general.

We would like to underline that this formula, perhaps it is not useful at all. But if it is, we are not suggesting that you

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have to use 500 as a multiplier; it might be 200 or what other number is reasonable. The point we feel is, if you are going to have an area which is not going to meet or cannot meet the standards at certain times because of conditions beyond the control of man, you are going to have to recognize it somehow and define it and that is it.

As far as shores are concerned, again I think this will have to be based on your own experience. Surely, the Wisconsin shore waters stand much further out in terms of quality than do Minnesota's because of the difference in shoreline. You have the shallow sloping shore with sediment and sand, particularly, on it, which gives you a different situation than the steep rocky Minnesota shore. These are things which you will have to take into account yourself.

What we are trying to say, the bulk of the lake, this is what we feel ought to exist in it. I think it is the lake as a whole that we are most concerned about in this conference and we do believe this is reasonable.

MR. VOGT: I think there are some other basic questions so far as these water quality criteria are concerned that need to be satisfied even before we get into the values that he might attach to some parameters. Those might have to be discussed when the conferees consider the recommendation.

MR. DOMINICK: That will be very satisfactory. If you have any discussion of these in your presentation from the State point of view, we will be happy to have that at that time.

Are there any other questions of Dr. Mount?

Mr. Bryson, if you would, give us the Federal Water Pollution Control Administration statement on the summary and

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conclusions of the report beginning on Page 46 and the recommendations beginning on Page 48.

STATEMENT OF DALE S. BRYSON,
DIRECTOR, LAKE SUPERIOR BASIN OFFICE,
FEDERAL WATER POLLUTION CONTROL
ADMINISTRATION, CHICAGO, ILLINOIS

MR. BRYSON: Reading from Page 46, the Summary and
Conclusions:

1. Lake Superior is a priceless natural heritage which the present generation holds in trust for posterity, with an obligation to pass it on in the best possible condition.
2. The esthetic value of Lake Superior is of major importance. The lake's deep blue appearance is a significant tourist attraction.
3. Because of the low mineral content of Lake Superior's waters, increases in the range of 2 to 50 parts per billion of heavy metals such as copper, chromium, zinc, and cadmium will have lasting deleterious effects upon the lake.
4. The extreme clarity and cold temperature of the waters of Lake Superior are a necessity to support its present ecology. A reduction in light penetration will significantly alter the types of life therein. The clarity of the lake is extremely susceptible to being reduced by Works, has a deleterious effect on the ecology of a portion of the lake by

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reducing organisms necessary to support fish life.

5. The portion of Lake Superior shallow enough to provide suitable fish spawning areas is limited to a small band around the shoreline. This area is most susceptible to the influence of natural and man-made sediments. Deposition on the bottom of fine particles discharged to Lake Superior is a threat to the inshore food producing area and to the incubation of important fish species.

6. Water quality criteria can be established to protect the esthetic value, recreational uses and the unique aquatic life of the lake and yet such that reasonable allowance is made for future municipal and industrial expansion.

7. Lake Superior is an oligotrophic lake. Nutrient values in some area of the lake have been reported at levels approaching those commonly associated with nuisance algal growths. However, other factors, such as temperature, are limiting.

8. Outflow from Lake Superior passes through Lakes Huron, Erie and Ontario. Dissolved chemicals in this outflow contribute to the levels found in these downstream lakes.

9. The discharge of taconite tailings to Lake Superior from the Reserve Mining Company, E. W. Davis Works, has a deleterious effect on the ecology of a portion of the lake by reducing organisms necessary to support fish life.

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10. The quantity of oxygen normally dissolved in water is one of the more important ingredients necessary for a healthy, balanced aquatic life. The discharge of treated and untreated municipal and industrial wastes with high concentrations of biochemical oxygen demand has caused oxygen depletion in the St. Louis River, Duluth-Superior Harbor, and Montreal River.

11. Watercraft plying the waters of Lake Superior are contributors of both untreated and inadequately treated wastes in local harbors and in the open lake, and intensify local pollution problems.

12. Oil discharges from industrial plants, commercial ships and careless loading and unloading of cargoes despoil beaches and other recreational areas, coat the hulls of boats and are deleterious to fish and aquatic life.

13. Evidence of bacterial pollution has been reported in the St. Louis River and Duluth Harbor area in Minnesota, and Superior Harbor area, Ashland inshore area, and reaches of the Montreal River in Wisconsin.

14. The maintenance of waterways for commercial and recreational use is a necessary activity. The deposition of polluted dredgings contributes to the degradation in quality of Lake Superior.

15. Adverse effects upon water quality and water uses of streams in the red clay area of northwestern Wisconsin is occurring as a result of land runoff from poor land management

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practices. The sediment contained in the discharges from streams in this area has an adverse effect on Lake Superior.

16. A persistent pollutant entering directly into the waters of Lake Superior or dissolved in the water that feeds the lake mixes with and becomes an integral part of a significant portion of the lake water.

17. Discharges of wastes originating in Michigan and Wisconsin cause pollution of the interstate Montreal River. Discharges of wastes originating in Minnesota and Wisconsin cause pollution in the interstate St. Louis River and Duluth-Superior Harbor. These discharges endanger the health or welfare of persons in States other than those in which such discharges originate. This pollution is subject to abatement under the provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.).

Now turning to the recommendations on Page 48:

It is recommended that:

1. Water quality criteria as shown in Table 3 (Page 44) be included as part of the interstate water quality standards on Lake Superior to reflect more appropriately the uniqueness of the lake.

2. The FWPCA and the States keep the discharge of taconite tailings to Lake Superior from the Reserve Mining Company, E. W. Davis Works, under continuing surveillance and report to the conferees at 6 month intervals on any findings that interstate pollution is occurring or is likely

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to occur, and the State of Minnesota is urged to take such regulatory actions as necessary to control the intrastate pollution resulting from these discharges, if any.

3. The FWPCA and the States adjust or modify water quality surveillance plants for the Lake Superior Basin to insure that plans are sufficiently sensitive to monitor changes in water quality. The FWPCA and States are requested to report to the conferees within six months concerning their program.

4. Secondary biological waste treatment be provided by all municipalities in the Lake Superior Basin. This action is to be accomplished by January 1973 or earlier if required by Federal-State water quality standards.

5. Continuous disinfection be provided throughout the year for all municipal waste treatment plant effluents. This action should be accomplished as soon as possible and not later than May 1970.

6. Continuous disinfection be provided for industrial effluents containing pathogenic organisms which indicate the presence of such pathogens. This action should be accomplished as soon as possible and not later than May 1970.

7. Waste treatment be provided by municipalities to achieve at least 80 percent reduction of total phosphorus from each State. This action is to be accomplished by January 1973, or earlier if required by Federal-State water quality standards.

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8. Industries not connected to municipal sewer systems provide treatment equivalent to that of municipalities so as not to cause the degradation of Lake Superior water quality. This action is to be accomplished by January 1973 or earlier if required by Federal-State water quality standards.

9. Each State water pollution control agency make necessary corrections to the list in Appendix A of municipal and industrial waste discharges to the Lake Superior Basin. In addition, information should be provided on each source to indicate whether it discharges pollutants, including nutrients, that have a deleterious effect on Lake Superior water quality. Detailed action plans for treatment of all wastes having deleterious effects should be developed, where not already completed. Such plans shall identify the principal characteristics of the waste material now being discharged, the quantities, the proposed program for construction or modification of remedial facilities and a timetable for accomplishment, giving target dates in detail. This list shall be presented to the conferees within six months.

10. Unified collection systems serving contiguous urban areas be encouraged.

11. Each of the State's water pollution control agencies accelerate programs to provide for the maximum use of area-wide sewage facilities to discourage the

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proliferation of small treatment plants in contiguous urbanized areas and foster the replacement of septic tanks with adequate collection and treatment.

12. Each State water pollution control agency list the municipalities or communities having combined sewers. The listing should include a proposed plan for minimizing bypassing so as to utilize to the fullest extent possible the capacity of interceptor sewers for conveying combined flow to treatment facilities. Construction of separate sewers or other remedial action to prevent pollution from this source is to be completed by October 1977.

13. Existing combined sewers be separated in coordination with all urban reconstruction projects except where other techniques can be applied to control pollution from combined sewer overflows. Combined sewers should be prohibited in all new developments.

14. Discharge of treatable industrial wastes to municipal sewer systems be encouraged.

15. The States institute necessary controls to ensure that the concentration of DDT in fish not exceed 1.0 micrograms per gram; DDD not exceed 0.5 micrograms per gram; dieldrin not exceed 0.1 micrograms per gram, and all other chlorinated hydrocarbon insecticides, singly or combined, should not exceed 0.1 micrograms per gram. Limits apply to both muscle and whole body and are expressed on the basis of wet weight of tissue.

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16. Uniform State rules and regulations for controlling wastes from watercrafts should be adopted. These rules and regulations should generally conform with the rules and regulations approved by the conferees to the Lake Michigan-Four State Enforcement Conference. Commensurate interstate requirements controlling the discharge of wastes from commercial vessels should be the responsibility of the Federal Government.

17. The dumping of polluted dredged material into Lake Superior be prohibited.

18. Programs to be developed by appropriate State and Federal agencies to control soil erosion in the basin. The action plan developed by the Red Clay Interagency Committee should become an integral part of the programs conducted by all appropriate agencies, groups, and private individuals.

19. The discharge of visible oil from any source be eliminated.

20. The recommendations of this enforcement conference be adopted as part of the State's enforceable water quality standards.

MR. DOMINICK: Thank you, Mr. Bryson

Are there any immediate questions?

MR. PURDY: Yes, Mr. Chairman, I have a couple of clarifying questions that I would like to enter into a full discussion of the findings and summary and conclusion and recommendations at some later time in the conference.

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However, in the Summary and Conclusion No. 12 it seems to indicate that oil discharges are now a problem. However, on Page 31 is the statement that oil pollution is presently not a problem in Lake Superior. It seems to be somewhat in conflict. Is oil a problem presently in Lake Superior?

MR. BRYSON: There have been isolated instances of oil pollution that have occurred, but, as the report says on Page 31, there have not been any major problems in the basin. The Summary and Conclusion No. 12 merely points out some of the problems that can occur in the event of a major spill, and also with the more limited spill these conditions can exist.

MR. PURDY: If one occurred this would happen?

MR. BRYSON: Would you repeat that? I can't hear you.

MR. PURDY: Are you saying that No. 12 indicates if oil is lost this is what would happen; it is not a finding that this is occurring at the present time?

MR. BRYSON: Isolated instances have occurred in the basin.

MR. PURDY: All right.

On No. 17 would you say that you have definitive information at the present time to reach a conclusion that discharges of waste originating in Michigan cause pollution of the international Montreal River?

MR. BRYSON: The discharges of waste into the Montreal River has caused an oxygen depletion problem. As my statement said earlier, the origin of the sources of the two wastes have not been determined.

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MR. PURDY: No. 17 seems to reach the conclusion that discharges of waste originating in Michigan and Wisconsin both cause pollution of the interstate Montreal River. I wonder if you have definitive information to reach that conclusion.

MR. BRYSON: In a report prepared by the State of Wisconsin, Bibliographical Reference No. 12, they report oxygen depletion problems in the Montreal River. As I said, the proportion of the problem created by discharging in Michigan versus discharging in Wisconsin was not determined by the FWPCA.

MR. PURDY: I think this would mean that you would have to have additional studies to reach this conclusion that it causes pollution of the interstate water.

MR. STEIN: As I understand it, it is oxygen depletion which causes pollution of the interstate waters. As we have looked at this -- and Michigan, too -- is that if there is pollution because of oxygen depletion the people contributing to the pollution are jointly and separately liable and both Michigan and Wisconsin have contributed to that. As long as they contribute, a source that is not the minimum and results in pollution, then they reach such a conclusion.

MR. PURDY: When we present our report we will have information on this and the quantity discharged from sources in Michigan.

MR. STEIN: Then we can make it. But the rule here, as you know, is that we don't use any rule differently than you do in State administration.

MR. PURDY: The original report indicated bacterial contamination from both Michigan and Wisconsin. I note from the comments

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presented this morning that the bacterial contaminations of Michigan sources has been eliminated from that part of the original report and I wondered if there could be any revision of this conclusion at the present time.

MR. DOMINICK: I believe if we receive your testimony we will take a look at this conclusion, but no revision should be attempted at the present time,

MR. PURDY: With respect to Recommendation No. 15, I think it might be valuable at some later point in time to have Dr. Mount review the basis of the recommendation with the conferees.

Also, I think it should be clear, if this recommendation relates to , say, the edibility of the flesh of the fish, this conference is concerned with this, I question this with the FWPCA interim tolerance level.

MR. DOMINICK: We would be happy to address ourselves to those questions. If you feel that Dr. Mount should testify further on that point, he will at an appropriate time.

MR. PURDY: I think we need additional information on it. But right at the moment this limit recommended here relates to the edibility of the fish, because the limit here is less than that now recommended by the FWPCA as a limited tolerance level.

MR. STEIN: I think we should call on Dr. Mount for that one.

Is Dr. Mount here?

DR. MOUNT: I am afraid I am here.

The limits that we recommended -- these, by the way, to state again, are the recommendations of the Lake Michigan Pesticide

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Committee that was appointed by the conferees at that conference.

There was a reasoning that went into these limits which were based upon what we felt was a healthy fish population in Lake Superior and these are the average levels that one finds in Lake Superior fish. This information comes from the Bureau of Commercial Fisheries Laboratory in Ann Arbor, and I think most of it has been done under the auspices or direction of Mr. Carr. These limits are in no way intended to relate to the edibility of fish. They refer to whole body measurements in this case and are intended to protect the health of the fish rather than the health of the people in this case. We have, I think, ample evidence to show that amounts of DDT in the water which will result in unacceptable residues as far as human consumption is concerned which may be quite different than those that will permit good survival of aquatic life.

MR. PURDY: Thank you.

MR. DOMINICK: Thank you, Dr. Mount.

If we have no further questions, the conference will be recessed until 9 o'clock tomorrow morning, at which time we will hear from the State of Minnesota.

(Whereupon, at 4:55 p.m., the conference adjourned until Wednesday, May 14, 1969, at 9:00 a.m.)

PHENOLS AND PHENOLIC COMPOUNDS

I. BIOLOGICAL EFFECTS. Phenols and substituted phenols are toxic to trout and other fish at concentrations of 0.1 to 10 mg/l. Studies of long term effects at lower concentrations have not been made.

Phenolic compounds, particularly the chlorophenols, cause unpleasant odors and flavors in fish from waters containing as little as 0.0001 mg/l. Most phenols are biodegradable, but at concentrations of a few mg/l or less cause nuisance slime and mold growths on rocks, etc.

II. SPECIAL CONSIDERATIONS. Phenols in drinking water are detectable by disagreeable taste and odor at concentrations of 0.001 to 0.01 mg/l, thus the U.S. Public Health Service Drinking Water Standard has been set at 0.001 mg/l. Current waste treatment practices (tertiary treatment) are highly efficient at removal of phenols; however, post-chlorination of the waste increases the proportion of taste and odor causing chlorophenols.

III. EXISTING CONDITIONS. Phenol as such is not routinely measured in Lake Superior. However, data from Duluth and the St. Mary's River indicate that total aromatics (including phenols) average less than 0.001 mg/l.

IV. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. Based on the potential for causing taste and odor problems in drinking water and in commercial fish, the recommended criteria for phenols in Lake Superior is a maximum concentration of 0.001 mg/l.

V. REFERENCES.

1. Brown, V.M., Jordan, D.H.M., and Tiller, B.A., 1967. The Effect of Temperature on the Toxicity of Phenol to Rainbow Trout in Hard Water. *Water Research* 1:587-594.
2. Pickering, Q.H., and Henderson, C., 1966. Acute Toxicity of Some Important Petrochemicals to Fish. *Journal Water Pollution Control Federation* 38 (9): 1419-1429.
3. Ryckman, D.W., Prabhakara Rao, A.V.S., and Buzzel, J.C., Jr. Behavior of Organic Chemicals in the Aquatic Environment: A Literature Critique. Published by the Manufacturers Chemists Association, Washington, D.C., Summer 1966.
4. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D.C., April 1968.

AMMONIA

I. BIOLOGICAL EFFECTS. Ammonia is a normal product of animal metabolism and the major nitrogenous excretion of fish and other freshwater animals. It enters water naturally also by microbial decomposition of decaying plant and animal material, in rain water and, under certain conditions, by the degradation of dissolved nitrites and nitrates. In addition, it enters water as a component of sewage, fertilizers, and numerous industrial wastes. Conversely, it serves as a nutrient for some of the algae. Its concentration is unlikely to remain constant in a normal aquatic environment, but tends to be decreased by conversion to nitrite and nitrate. Because of its many possible sources and fates, the ammonia content of natural unpolluted waters is highly variable, and has been reported to range from 0.0 to about 4.0 mg/l, although usually less than 0.2 mg/l.

The experimental work to date on ammonia toxicity does not provide clear guidelines, partly because the distinction has not always been made between the highly toxic ammonia molecule and the less toxic ammonium ion, and partly because the experiments have been too crude to be related to long-term effects. A concentration of 1.5 mg/l has been reported as "not harmful to fish", but it has also been reported, however, that 1 mg/l and even 0.3 mg/l can affect the oxygen carrying capacity of the blood. Its effects on important fish food organisms of the lake are not known.

II. SPECIAL CONSIDERATION. The higher the pH the greater the proportion of toxic molecular ammonia relative to ammonium ion, the toxicity of ammonium compounds increasing by 200% or more between pH 7.4 and 8.0. Over the period 1958-1968 the pH of Lake Superior water at Duluth has ranged between 7.3 and 8.5, with a mean of 7.72, which is in a critical range for ammonia. Further, because of its low salt concentration Lake Superior water is poorly buffered against changes in pH. For these reasons the standard for ammonia must be extremely conservative to be safe for aquatic life.

III. EXISTING CONDITIONS. Over the period 1959-1966 at Sault Ste. Marie, and 1958-1965 at Duluth, the reported ammonia concentrations ranged between 0.0 and 0.1 mg/l as ammonia nitrogen, with means of 0.071 and 0.0024 mg/l, respectively.

IV. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. Since the values so far recorded seem not to have had an adverse effect, since the ammonia concentration is highly labile, and since ammonia is most toxic at high pH ranges, the recommended criteria is a maximum of 0.1 mg/l, expressed as ammonia nitrogen, and 90% of the values should be less than 0.05 mg/l.

V. PERTINENT REFERENCES.

1. Doudoroff, P., and Katz, M., 1950 22:1432-1458. Critical Review of Literature on the Toxicity of Industrial Wastes and their Components to Fish. I. Alkalies, Acids and Inorganic Gases. Sewage and Industrial Wastes.
2. Ellis, M. M. 1937. Bulletin U. S. Bureau of Fisheries. Detection and Measurement of Stream Pollution. Vol. 48: 365-437.
3. Goldstein, L., Forster, R. P. and Fanelli, G. M., Jr. 1964. Gill Blood Flow and Ammonia Excretion in the Marine Teleost, Myoxocephalus scorpius. Comp. Biochem. Physiol. 12: 489-499.
4. Lloyd, R. 1961. Effect of Dissolved Oxygen Concentrations on the Toxicity of Several Poisons to Rainbow Trout. Journal Experimental Biology. 38: 447-456.

PHOSPHORUS

I. **BIOLOGICAL EFFECTS.** Phosphorus is an essential nutrient which frequently occurs in minute quantities in natural waters and can thereby be limiting to the growth of aquatic plants. When present in excess, however, under favorable environmental conditions, it is instrumental in producing heavy and undesirable growths of both algae and rooted aquatic plants. Results obtained by various workers (e.g., Sawyer, 1947; Chu, 1943; Strickland, 1965; and Sylvester, 1961) indicate that phosphorus does not become limiting to algae until concentrations as low as 0.01 mg/l or less of soluble phosphorus are reached.

II. **SPECIAL CONSIDERATIONS.** Phosphorus, in increased quantities, is commonly associated with accelerated lake eutrophication. The degree to which aquatic plant growth is stimulated by phosphorus is variable, and will depend on the occurrence of other essential nutrients, temperature, light, etc. Phosphorus is, however, a substance which is essential to plant growth, one which is frequently limiting, and one which is much more amenable to control than many other nutrients. Nitrogen, for example, is difficult to control because some forms of algae are able to fix atmospheric nitrogen.

III. **EXISTING CONDITIONS.** Data on phosphorus distribution in Lake Superior are scarce. A synthesis of data published by Putnam and Olson (1960) and by Beeton, et al. (1959), indicate average distribution of total phosphorus, as mg/l Phosphorus, for all depths, to be as follows:

West End (West of Apostle Islands)	0.009
Apostle Islands Region	0.014
Open Lake, Apostle Islands to Keweenaw Peninsula	0.010
Keweenaw Bay	0.011
Coastal Waters off Marquette and Munising	0.010
Open Lake, East End	0.005
Whitefish Bay	0.006

The average for the entire lake is 0.0096 mg/l.

IV. **RECOMMENDED CRITERIA FOR LAKE SUPERIOR.** The total phosphorus levels should not be permitted to exceed existing values. Where background data are not available the maximum value should not exceed 0.01 mg/l total phosphorus.

V. REFERENCES.

1. Beeton, A. M., J. H. Johnson, and Stanford H. Smith, 1959. Lake Superior Limnological Data. U.S. Fish and Wildlife Service. Special Scientific Report - Fisheries No. 297, Washington, D. C., 177 p.
2. Chu, S. P., 1943. The Influence of the Mineral Composition of the Medium on the Growth of Planktonic Algae. Part II. The Influence of the Concentration of Inorganic Nitrogen and Phosphate Phosphorus. *J. Ecology* 31:109.
3. Putnam, H. D., and T. A. Olson. An Investigation of Nutrients in Western Lake Superior. School of Public Health, University of Minnesota, Duluth, for the Minnesota Water Pollution Control Commission, 1960.
4. Putnam, H. D., and T. A. Olson, 1966. Primary Productivity at a Fixed Station in Western Lake Superior. Proceedings, Ninth Conf. on Great Lakes Res., Inst. of Sci. and Tech., University of Mich., Ann Arbor, p. 119-128.
5. Sawyer, C. N., 1947. Fertilization of Lakes by Agricultural and Urban Drainage. *J. NEWWA*, 61:109.
6. Strickland, J. D. H., 1965. Production of Organic Matter in the Primary Stages of the Marine Food Chain. *Chemical Oceanography* (J. P. Riley and D. Skirrow, eds.), Academic Press, New York.
7. Sylvester, R. O., 1961. Nutrient Content of Drainage Water from Forested, Urban, and Agricultural Areas. Algae and Metropolitan Wastes, Public Health Service, SEC TR W61-3, 80, U.S. Govt. Print. Off., Washington, D. C.

IRON

I. **BIOLOGICAL EFFECTS.** Iron causes problems of taste, color and odor in water supplies and may stimulate the growth of bacteria and other lower plant life. It will discolor shore areas and may coat water conduits. Concentrations in excess of 0.3 mg/l cause taste problems and stain laundry. Lesser concentrations in combination with manganese often result in undesirable growths.

II. **SPECIAL CONSIDERATIONS.** Iron solubility is highly pH dependent. In more desirable pH values of 6.5 to 8.5 it occurs in the oxidized state and is rather insoluble and usually settles. Introductions of iron may result in an increase in settleable solids content in this way. Iron will redissolve in hypolimnionic waters under certain conditions and then may cause taste and odor problems.

III. **EXISTING CONDITIONS.** The ten year average concentration at Duluth is 0.023 mg/l and 0.019 mg/l at the St. Mary's River. The high value recorded is 0.168 mg/l. Highest readings occurred during the last several years.

IV. **RECOMMENDED CRITERIA FOR LAKE SUPERIOR.** The maximum value should be 0.1 mg/l and 90% of the values should be less than 0.03 mg/l at any single location.

V. **REFERENCES.**

1. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C. April 1968.
2. U. S. Department of Health, Education and Welfare, 1962, Public Health Service Drinking Water Standards, PHS Publication No. 956.
3. Water Quality Criteria, California State Water Quality Control Board, Sacramento, California, Publication 3-A, 1963. pp. 215

CADMIUM

I. BIOLOGICAL EFFECTS Cadmium occurs in small amounts in naturally occurring zinc ores reflecting its close chemical relationship to zinc but in natural waters occurs in only trace amounts. Cadmium is a nonessential, nonbeneficial element. It is a heavy metal that accumulates in animal tissues and has a high pollution potential because of its high toxicity and cumulative effects.

In the U.S. Public Health Service Drinking Water Standards, cadmium in excess of 0.010 mg/l constitutes grounds for rejection of the supply. Long term toxicity studies conducted at the Federal Water Pollution Control Administration's Newtown Fish Toxicology Laboratory have shown slow accumulative mortality in young fish and that newly hatched fry are extremely sensitive to cadmium. These chronic studies conducted in hard water (in which cadmium is less toxic than in Lake Superior) gave a "safe" concentration of 0.037 mg/l. The test concentration of 0.057 mg/l was lethal to newly hatched fry.

II. SPECIAL CONSIDERATION. The toxicity of cadmium, like the other heavy metals, is influenced by water quality characteristics, such as pH and hardness. Acute toxicity studies indicate that the lethal concentration of cadmium in softer water is 1 mg/l.

III. EXISTING CONDITIONS. According to Kopp and Kroner, of 66 samples in the Western Great Lakes Basin the frequency of detection (0.45 millipores filtered samples) was 3%. They did not detect cadmium in Lake Superior.

IV. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. The recommended criteria for cadmium in Lake Superior is a maximum value of 0.005 mg/l and 90% of the measurements less than 0.002 mg/l at a single location.

V. REFERENCES.

1. Pickering, Q. H., and Gast, M. The Chronic Toxicity of Cadmium to the Fathead Minnow (*Pimephales promelas*) (In preparation).
2. Pickering, Q. H., and Henderson, C. Acute Toxicity of Some Heavy Metals to Different Species of Warm Water Fishes, Proceedings 19th Industrial Waste Conference. Purdue University. 1965.

CHROMIUM

I. BIOLOGICAL EFFECTS. In the U. S. Public Health Service Drinking Water Standards the presence of hexavalent chromium in excess of 0.05 mg/l shall constitute grounds for rejection of the supply. Chromium is not known to be either an essential or beneficial element in animals. There is accumulation of chromium in many animals and when inhaled, chromium is a known cancerigenic agent for man. Trivalent chromium is not of concern in drinking water supplies at present.

In long-term tests conducted at the Federal Water Pollution Control Administration's Newtown Fish Toxicology Laboratory, in a hard water, 1 mg/l of hexavalent chromium was found to be a "safe" concentration for survival and reproduction of the fathead minnow. The lethal value in a similar water (200 mg/l hardness) was 33 mg/l. In a soft water, low pH bioassay the lethal value for the fathead minnow was 17 mg/l.

Bioassays conducted with four species gave lethal values of hexavalent chromium that ranged from 17 to 118 mg/l. Thus it appears that there is a great range of sensitivity of various fish species. Hexavalent chromium appears to be more toxic to some invertebrates; 0.05 mg/l is lethal to *Daphnia*, a very important animal in Lake Superior. In acute bioassays trivalent chromium is more toxic in soft water than hexavalent chromium. The chronic studies indicated that their toxicity is not greatly different.

II. Special Considerations. Hexavalent chromium is very soluble in water while trivalent chromium is much less soluble, especially in hard water. Many variables influence the toxicity of chromium. Trama and Benoit have shown that the toxicity of hexavalent chromium is dependent on pH; it is more toxic under conditions of low pH. The toxicity of trivalent chromium is dependent on concentration, pH, hardness, and equilibrium state.

III. EXISTING CONDITIONS. Hexavalent chromium concentrations found in Lake Superior at Duluth had a frequency of detection of 40%. In these samples of positive occurrence the mean concentration was 9 µg/l and the maximum was 20 µg/l. At St. Mary's River hexavalent chromium was found in 17% of the samples with a mean of 3 µg/l and a maximum of 7 µg/l. Data are not available for trivalent chromium concentrations.

IV. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. The recommended criteria for total chromium is a maximum of 0.050 mg/l and 90% of the values should be less than 0.02 mg/l at any single location.

V. REFERENCES.

1. Pickering, Q. P., and Henderson, C. Acute Toxicity of Some Heavy Metals to Different Species of Warmwater Fishes, Proceedings 19th Industrial Waste Conference, Purdue University, 1965.
2. Trama, F. B., and Benoit, R. J. Toxicity of Hexavalent Chromium to Bluegills, Journal Water Pollution Control Federation, Volume 32, 1960.

COPPER

I. **BIOLOGICAL EFFECTS.** Copper is one of the more toxic of the heavy metals to many desirable aquatic organisms. It is also an essential trace element and is often added to the foods of both aquatic and terrestrial animals. It is commonly used to control algal growths in water supplies. The permissible concentration in public water supplies is 1 mg/l and the desirable concentration is virtually absent.

Experiments with trout, perch, sunfish, freshwater shrimp, *Daphnia*, snails, and clams establish the maximum no-effect concentrations in Lake Superior water to be between 0.01 and 0.05 mg/l. Trout, shrimp, and *Daphnia*, all important in Lake Superior, are among the most sensitive. To some animals, copper concentrations that kill are substantially higher than concentrations that retard growth and inhibit reproduction. Experimentation has shown that concentrations 1/10 to 1/30 of the lethal concentrations inhibit reproduction.

II. **SPECIAL CONSIDERATION.** Both pH and the calcium-magnesium content of water affects copper toxicity to aquatic organisms. The lethal concentrations are more affected by these characteristics than are the no-effect concentrations. Lake Superior water has low concentrations of calcium and magnesium and therefore copper is more toxic in it than in most other natural waters of the United States. For this reason, stringent criteria are needed.

III. **EXISTING CONDITIONS.** Five year average concentrations of copper at Duluth and the St. Mary's River are 0.003 and 0.005 mg/l, respectively. Some values have been reported as high as 0.02 mg/l, but nearly all are less than 0.01 mg/l. Except near sources of copper introduction, concentrations do not vary greatly.

IV. **RECOMMENDED CRITERIA FOR LAKE SUPERIOR.** The criteria for Lake Superior should be a maximum of 0.012 mg/l and 90% of the measurements should be less than 0.008 mg/l at any single location.

V. REFERENCES.

1. Sprague, J. B., Lethal Concentrations of Copper and Zinc for Young Atlantic Salmon, *Journal of Fisheries Research Board, Canada*, 21 (1), 1964.
2. Mount, Donald I. Chronic Toxicity of Copper to Fathead Minnows (*Pimephales Promelas*, Rafinesque). *Water Research*, 2:215-223, 1968.
3. Grande, Magne., Effect of Copper and Zinc on Salmonid Fishes, Third International Conference on Water Pollution Research, Section 1, Paper No. 5.
4. Sprague, J. B., Avoidance of Copper-Zinc Solutions by Young Salmon in the Laboratory. *Journal Water Pollution Control Federation*, Vol. 36 (8): 990-1004, 1964.
5. (Personal communication, National Water Quality Laboratory Staff.) Acute and Chronic Effects of Cu^{+2} on Fish and Invertebrates in Lake Superior Water, 1969.

LEAD

I. **BIOLOGICAL EFFECTS.** Lead is quite poisonous to aquatic organisms, concentrations of 0.1 mg/l having killed fish in soft water. In water more like that of Lake Superior, however, short term (a few hours to a few days) mortality test values of from 5 to 50 mg/l of lead have often been obtained.

The few longer term (up to six months), nonlethal exposures to lead in water have demonstrated that accumulations in various parts of the body result from continuous uptake of lead by the fish. Such accumulations in mammals have led to toxic effects and death after long periods of time, even many years. On the basis of available information on fish, similar results would be expected.

Daphnia in Lake Superior water are killed in a few days by an 0.5 mg/l concentration; mayflies, stoneflies, and caddisflies are killed at 16 to 64 mg/l concentrations.

II. **SPECIFIC CONSIDERATIONS:** Because of lead's low solubility in comparison with many other metal salts, pH and calcium-magnesium content of water are particularly important in determining its toxicity. High lead concentrations are particularly significant in the soft water of Lake Superior.

III. **EXISTING CONDITIONS.** The average concentration of lead in filtered water at the St. Mary's River over the five year period ending September 30, 1967 was 0.006 mg/l. Two filtered samples taken at Duluth during this period contained 0.007 and 0.02 mg/l. The average of 20 unfiltered samples taken at scattered sites in Lake Superior during 1967 is 0.027 mg/l. This figure excludes one very high and probably incorrect value of 0.306 mg/l that was found in a sample taken near the center of the lake.

IV. **RECOMMENDED CRITERIA FOR LAKE SUPERIOR.** The Public Health Service Drinking Water Standard of 0.05 mg/l should never be exceeded and 90% of the measurements should be less than 0.03 mg/l at any single location.

V. REFERENCES.

1. McKee, J. E., and Wolf, H. W., Water Quality Criteria, Publication No. 3-A, California State Water Quality Control Board, Second Edition, 1963.
2. Pickering, Q. H., and Henderson, C., 1966. The Acute Toxicity of Some Heavy Metals to Different Species of Warmwater Fishes. Air-Water Pollution International Journal 10:457-463.
3. Warnick, S. F., and Bell, H. L., 1969. The Acute Toxicity of Some Heavy Metals to Different Species of Aquatic Insects. Journal of Water Pollution Control Federation. 41:280-284.
4. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C. April 1968.
5. U.S. Department of Health, Education and Welfare, 1962, Public Health Service Drinking Water Standards, PHS Publication No. 956.

NICKEL

I. BIOLOGICAL EFFECTS. The U.S. Public Health Service Drinking Water Standards do not place any concentration limits on nickel. It is a nonessential element, and its toxicity to mammals appears to be very low. However, nickel may be very toxic to some plants.

The lethal concentration of nickel in soft water (20 mg/l hardness) to the fathead minnow is about 5 mg/l and in hard water (360 mg/l hardness) it is about 43 mg/l. With continuous-flow testing the lethal concentration is 20 mg/l in water of 200 mg/l hardness. Using these data, the estimated lethal concentration in Lake Superior water (44 mg/l hardness) would be 7 mg/l of nickel. Some Lake Superior fish are more sensitive, however.

In a long-term bioassay conducted with a water of 200 mg/l hardness at the Federal Water Pollution Control Administration's Newtown Fish Toxicology Laboratory, the "safe" concentration was 0.4 mg/l nickel. At this concentration the fathead minnow lived, grew, and reproduced.

II. SPECIAL CONSIDERATIONS. Certain environmental variables affect toxicity of nickel, but toxicity is not affected by hardness as much as for other metals. Various types of aquatic life differ considerably in sensitivity to nickel.

III. EXISTING CONDITIONS. Concentrations of nickel in the Western Great Lakes Basin were found in 9% of the samples. In the samples with positive occurrence, the mean concentration was 0.01 mg/l and the maximum concentration was 0.328 mg/l. Nickel was not detected at Duluth.

IV. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. Nickel should not exceed a maximum of 0.03 mg/l and 90% of the values should be less than 0.015 mg/l at a single location.

V. REFERENCES.

1. Pickering, Q. P. and Henderson, C., Acute Toxicity of Some Heavy Metals to Inherent Species of Warmwater Fishes, Proceedings 19th Industrial Waste Conference, Purdue University, 1965.

ZINC

I. BIOLOGICAL EFFECTS. Zinc is one of several heavy metals occurring almost universally in surface waters. These natural levels of zinc vary greatly and are influenced by minerals in soils and characteristics of the water itself. Zinc is an essential trace metal for aquatic life, yet inhibits fish production at quite low concentrations.

Long-term tests with the fathead minnow in which the fish were continuously exposed to a series of zinc concentrations during the entire life cycle indicate that concentrations significantly inhibiting reproduction are much lower than the lethal concentrations or those that have demonstrated some histological or physiological changes. These studies were conducted in water with higher calcium, magnesium and pH than that found in Lake Superior water and therefore zinc was less toxic under the test conditions. A decrease in reproduction occurred at a zinc concentration of 0.045 mg/l in hard water. Since the test was conducted in a harder water than that of Lake Superior and the toxicity of zinc increases as the calcium-magnesium level decreases, the safe level in Lake Superior is lower than 0.045 mg/l. Zinc partially reduces reproduction over a wide range of concentrations and there is no sharp threshold.

II. SPECIAL CONSIDERATIONS. Many environmental variables affect the toxicity of zinc. Principal examples would be the calcium-magnesium content of the water, pH, temperature, and differential sensitivity of aquatic species. Such factors prohibit the selection of a single criterion for all freshwater environments.

III. EXISTING CONDITIONS. The mean zinc concentration in water taken at the Duluth, Minnesota, water treatment plant was 0.009 mg/l and at the St. Mary's River, 0.030 mg/l. The current permissible level of zinc in public water supplies is 5 mg/l. The high values recorded in St. Mary's River are of concern.

IV. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. Zinc concentrations should not exceed 0.015 mg/l and 90% of the values should be less than 0.010 mg/l.

V. REFERENCES.

1. Brungs, W.A. Chronic Toxicity of Zinc to the Fathead Minnow (*Pimephales Promelas*, Rafinesque). Transaction American Fisheries Society, April 1969.
2. Mount, D.I. The Effect of Total Hardness and pH on Acute Toxicity of Zinc to Fish. Air and Water Pollution International Journal, 10:49-56 (1966).
3. Skidmore, J.F. Toxicity of Zinc Compounds to Aquatic Animals, with Special Reference to Fish. The Quarterly Review of Biology, 10 (3): 227 (Sept. 1964).
4. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C. April 1968.

CYANIDE

I. **BIOLOGICAL EFFECTS.** Cyanide is a highly poisonous chemical and occurs principally from industrial processes. It combines with haemoglobin in blood, forming a rather stable complex, and reduces the oxygen-carrying capacity of the blood. It is poorly removed by normal water treatment processes.

Experiments with trout and bluegills resulted in total kill at 0.05 mg/l and other adverse effects as low as 0.005 mg/l.

The U.S. Public Health Service Drinking Water Standard is 0.3 mg/l and the desirable concentration is virtually zero.

II. **SPECIAL CONSIDERATIONS.** Cyanide toxicity to aquatic life forms is highly pH dependent. Undissociated hydrocyanic acid is most toxic and this is present in the largest proportion at low pH values. It combines readily with heavy metals and may be more or less toxic than the uncombined form, depending on the particular complex.

III. **EXISTING CONDITIONS.** Average concentrations at both Duluth and the St. Mary's River are less than 0.001 mg/l.

IV. **RECOMMENDED CRITERIA FOR LAKE SUPERIOR.** The maximum concentration should not exceed 0.004 mg/l and 90% of the values should be less than 0.002 mg/l at any location.

V. REFERENCES.

1. Biology of Water Pollution, U.S. Department of the Interior, Federal Water Pollution Control Administration, 1967.
2. U.S. Department of Health, Education and Welfare, 1962, Public Health Service Drinking Water Standards, PHS Publication No. 954.
3. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D.C. April, 1968.
4. Cairns, John. Notulae Naturae, #361, July 30, 1963.
5. Doudoroff, P. Transactions of the American Fishery Society, Vol. 95, No 1, Jan. 1968.

I. BIOLOGICAL EFFECTS. Sulfides in water are the result of natural processes of decomposition in enriched waters, sewage, and industrial wastes such as those from oil refineries, tanneries, pulp and paper mills¹ chemical plants, and gas manufacturing facilities. Sulfides are produced by the action of anaerobic organisms on sulfates and organic sulphur compounds. Hydrogen sulfide contributes to taste and odor of water supplies that can be detected by man at 0.005 - 0.010 mg/l² and taints flesh of aquatic organisms.

Experiments with eggs and fry of trout, walleye, northern pike, suckers, and immature blue gills and fathead minnows indicate lethal concentrations of undissociated hydrogen sulfide to vary between 0.008 - 0.058 mg/l². Trout fry are killed in three days at 0.020 mg/l at high oxygen levels. Freshwater shrimp are more sensitive than fish fry.

II. SPECIAL CONSIDERATION. Hydrogen sulfide decays exponentially with a half life of one hour in oxygenated water.³ However, it can be evolved into oxygenated water from organic deposits and can be found at lethal concentrations at the bottom-water interface.¹ The toxicity of an effluent may bear no relation to its potential toxicity in organic deposits. Fish eggs, fry, and food organisms are most susceptible.⁴ Since most species of sport and commercial value in Lake Superior spawn at depths of 100 fathoms or less,⁴ it is important that good water quality be maintained to this depth at the bottom-water interface.

Fish fry are more sensitive to hydrogen sulfide at low oxygen concentrations.² The toxicity of sulfide increases markedly with a decrease in pH because there is more undissociated hydrogen sulfide present.

III. EXISTING CONDITIONS. No measurements of dissolved sulfide have been recorded for Lake Superior, however, it is unlikely that any accumulation has occurred since high oxygen levels are found even at 250 meters.

IV. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. The recommended criteria is a maximum of 0.02 mg/l and 90% of the values less than 0.002 mg/l as total sulfide measured at the bottom-water interface.

V. LITERATURE CITED.

1. Colby, Peter J., and Smith, Lloyd L., Jr., 1967. Survival of Walleye Eggs and Fry on Paper Fiber Sludge Deposits in Rainy River, Minnesota. Transactions American Fisheries Society 96 (3) 278-296.
2. Unpublished Data, Department Entomology Fish and Wildlife, University of Minnesota, St. Paul.
3. Hayes, F. R., Reid, B. L. and Cammeron, M. L. 1958. Lake Water and Sediment. II. Oxidation-Reduction Relations at Mud-water Interface. Limnology and Oceanography 3: 306-317.
4. Unpublished Data, Bureau of Commercial Fisheries, Ashland, Wisconsin.
5. Longwell, J. and Pentelow, F. T. K. 1935. The Effect of Sewage on Brown Trout (*Salmo trutta* L.) Journal Exp. Biology 12: 1-12.

TASTE AND ODOR

I. GENERAL CONSIDERATIONS. Tastes and odors affect principally municipal water supplies and beverage industries. In places, tainting of fish flesh occurs and causes impairment of the water for fish production. Great expense is incurred at some treatment plants in other areas of the country because activated carbon treatment is needed to remove tastes and odors.

II. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. Taste and odor do not exist at present in Lake Superior, and in order to avoid expensive treatment in the future, substances causing taste and order should not be permitted. Chloroform extracts should not exceed a maximum of 0.05 mg/l and 90% of the values should be less than 0.03 mg/l. Threshold odor numbers should not exceed 3 and 90% of them less than 1.

III. REFERENCES.

1. U. S. Department of Health, Education and Welfare, 1962, Public Health Service Drinking Water Standards, PHS Publication No. 956.
2. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C. April 1968.
3. Microbiology for Sanitary Engineers. McKinney. 1962.
4. Duluth Municipal Water Supply. Ten Year Composite Log Annual Reports, Duluth, Minnesota. 1968.
5. Quality of Waters, Minnesota - a Compilation - Taste and Odor, 1955 - 1962, State of Minnesota, Department of Conservation, Division of Waters, Bulletin 21, June 1963.

TEMPERATURE

I. GENERAL CONSIDERATIONS. Temperature affects all physical, chemical, and biological processes in Lake Superior. If the normal temperature regime is altered the complete balance of the lake will be changed. An increase in temperature is known to accelerate the aging process of lakes, increase the toxicity of chemicals, lower dissolved oxygen levels, increase algal growths, disrupt delicate biological cycles, and endanger many important sensitive organisms.

Increases in the water temperature of Lake Superior will require more stringent water quality standards for other parameters.

II. BIOLOGICAL EFFECTS. The valuable lake trout, herring and whitefish of Lake Superior require cold water for their survival. Complete mortality of developing embryos is known to occur at 12°C (54°F.). Significant reduction in hatch occurs above 60°C (43°F.) among the coregonid fishes. Most of the important fish in Lake Superior spawn in the fall (Oct., Nov., Dec.) in response to falling temperatures, requiring temperatures of about 10°C (50°F.) or less to initiate the response. Incubation of the eggs which are found on the lake bottom is best below 6°C (43°F.). Optimum incubation occurs at 0.5°C (33°F.) for the lake whitefish (*Coregonus clupeaformis*) and 2°C (36°F.) or less for the lake herring (*C. artedii*). Upon hatching in the spring the young fish move into surface waters and at this time exhibit greater temperature tolerance than the incubating eggs. Exposure to temperatures of 15°C (59°F.) will be tolerated by lake herring fry for extended periods without increased mortality rates. Temperature between 18 - 21°C (64-70°F.) will be tolerated for lesser periods but extended exposure to these temperatures increases rate of mortality markedly.

III. SPECIAL CONSIDERATIONS.

A. Heated effluents should not contribute to temperatures of water so as to cause them to serve as barriers to the movement of anadromous fish to and from their spawning and rearing areas.

B. Discharge of heated effluents should be to the epilimnion, unless a special study indicates a more desirable discharge point, because the important fish species in Lake Superior are deep water dwellers much of the time.

IV. EXISTING CONDITIONS. Lake Superior is a cold clear, oligotrophic lake. It usually does not exhibit well defined temperature stratification until mid-July and even then the stratification is not uniform from area to area and the thermocline is poorly developed. The lake may mix to great depths and homothermous water around 2°C (36°F.) has been found to occur to depths of 600 ft. The deep water remains near 4°C (39°F.) through the year. Yearly average temperatures from Duluth and St. Mary's River are 8.5°C (47°F.) and 7.3°C (45°F.).

Nine year average temperatures at St. Mary's River, given as quarterly averages are:

	Average of Quarterly Mean	Average of Quarterly Maximum
I. (Jan., Feb., Mar.)	- 0.7° C (33° F)	2.3° C (36° F)
II. (Apr., May, June)	- 5.5° C (42° F)	14.9° C (59° F)
III. (July, Aug., Sept.)	- 15.0° C (61° F)	20.4° C (69° F)
IV. (Oct., Nov., Dec.)	- 7.0° C (45° F)	13.8° C (57° F)

Average temperatures along the North Shore and mid-lake are below these temperatures while averages for areas along the South Shore (Calumet, Marquette, etc.) are similar and occasionally somewhat higher.

These are the maximum values for Lake Superior obtained from the literature as referenced.

I. (Jan., Feb., Mar.)	- Mean	1.3° C (34° F)	Soo (St. Mary's R.)	1965 NWQN
	- Max.	2.8° C (37° F)	Marquette	1954 Beeton
II. (Apr., May, June)	- Mean	6.8° C (44° F)	Soo (St. Mary's R.)	1964 NWQN
	- Max.	17.2° C (63° F)	Calumet	1955 Beeton
III. (July, Aug., Sept.)	- Mean	17.9° C (64° F)	Soo (St. Mary's R.)	1966 NWQN
	- Max.	25.0° C (77° F)	Calumet	1953 Beeton
IV. (Oct., Nov., Dec.)	- Mean	7.6° C (46° F)	Soo (St. Mary's R.)	1963 NWQN
	- Max.	13.9° C (57° F)	Calumet	1953 Beeton

TEMPERATURE (Con't)

V. RECOMMENDED CRITERIA FOR LAKE SUPERIOR.

A. The recommended quarterly mean and maximum surface¹ water temperatures² for Lake Superior that are not to be exceeded are given below:

I.	(Jan., Feb., March):	Mean-	2° C (36° F)
		Maximum-	5° C (41° F)
II.	(April, May, June):	Mean-	10° C (50° F)
		Maximum-	18° C (64° F)
III.	(July, Aug., Sept.):	Mean-	18° C (64° F)
		Maximum-	21° C (70° F)
IV.	(Oct., Nov., Dec.):	Mean-	8° C (46° F)
		Maximum-	15° C (59° F)

¹ less than 1 meter (3 ft.).

² based on continuous temperature monitoring.

B. Water temperatures of 6° C (43° F) shall never be exceeded at depths of 20 fathoms (120 ft.) or greater.

C. The water depth between 3 feet and 120 feet shall be a zone temperature transition.

VI. REFERENCES.

1. Beeton, A. M., Johnson, J. H. and Smith, S. H., 1959. Lake Superior Limnological Data. U. S. Fish and Wildlife Service Special Science Report - Fisheries No. 297, Washington, D. C., 177 pp.
2. Breder, C. M. Jr., and Rosen, D. E., 1966. Modes of Reproduction in Fishes, American Museum of Natural History, Garden City, New York.
3. Dryer, W. R., 1966. Bathymetric Distribution of Fish in the Apostle Island Region of Lake Superior. Transactions of American Fisheries Society. 95 (3): 248-259.
4. National Water Quality Laboratory: Thermal Studies, 1966-1969. Unpublished Data.
5. National Water Quality Network (1957-1968) Annual Compilation of Data. (Storet Retrieval System). U. S. Department of Health, Education and Welfare, Washington, D. C.
6. Price, John W., 1940. Time-temperature Relations in the Incubation of the Whitefish, *Coregonus clupeaformis* (Mitchill). Journal General Physics (4) 23: 449-468.
7. Ruschmeyer, O. R. and Olson, T. A., 1958. Water Movements and Temperatures of Western Lake Superior. School of Public Health, University of Minnesota, for Minnesota Water Pollution Control Commission, 86 pp.
8. Tait, J. S., 1960. The First Filling of the Swim Bladder in Salmonids. Canadian Journal of Zoology. 38: 179-187.
9. Wells, LaRue, 1966. Seasonal and Depth Distribution of Larval Bloaters (*Coregonus hoyi*) in Southeastern Lake Michigan. Transactions of American Fisheries Society. 95 (4): 388-396.

pH

I. GENERAL CONSIDERATIONS. Most organisms of esthetic and commercial importance live in water within an extremely narrow pH range. The pH concentration is governed by many inorganic chemicals and biological processes. Excessive additions of domestic or/and industrial wastes result in pH changes and can therefore make water unsuitable for desirable organisms. Thus it is important to control pH which in turn will regulate other water quality parameters.

II. BIOLOGICAL EFFECTS. Rudolfs, et. al. (1953) states that a pH range from 6.5 to 8.4 is tolerated by most fish. Chandler (1940) suggests values between 7.5 to 8.4 to be best for plankton production. Ellis (1937) found that most inland waters having fish have pH values between 6.7 and 8.6. Hart, et. al. (1945) report that only 5% of the waters in the United States supporting a good fish population have pH less than 6.7 whereas 95% have a pH less than 8.3. Parsons (1968) found the greatest number of species of plankton, benthos, and fishes to be in stream sections with a pH of 6.8 and above.

Work with pH at the National Water Quality Laboratory suggests that pH values below 6.0 inhibit or reduce spawning success with fathead minnows, and are lethal to Daphnia magna and new Gammarus pseudolimnaeus.

III. SPECIAL CONSIDERATIONS. Permissible criteria for public water supplies given in Water Quality Criteria (1968) give a range of pH from 6.0 - 8.5.

IV. EXISTING CONDITIONS. Lake Superior is an oligotrophic lake low in total dissolved solids and rather poorly buffered. Beeton (1959) gives pH values ranging from 6.9 to 8.0 in 1953 for samples taken at various depths in the open lake; however, most values were between 7.3 and 7.7. The maximum, minimum and mean pH values in Lake Superior were:

	Lake Superior at Duluth	St. Mary's River at Sault Ste. Marie
Years	1958 - 1968	1960 - 1968
No. Samples	543	457
Maximum	8.5	8.3
Minimum	7.3	6.8
Mean	7.7	7.8

V. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. The pH in Lake Superior should remain between 6.8 to 8.5.

VI. REFERENCES.

1. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C., April 1968.
2. Beeton, A. M., J. H. Johnson, and S. H. Smith, 1959. Lake Superior Limnological Data. U. S. Fish and Wildlife Service Special Science Report -- Fisheries No. 297, Washington, D. C., 177 pp.
3. Chandler, D. C., 1941. Limnological Studies of Western Lake Erie. I. Plankton and Certain Physical-Chemical Data on the Bass Islands Region, from September 1938 to November 1939. Ohio Journal of Science 40, 291.
4. Ellis, M. M., 1937. Detection and Measurement of Stream Pollution (Related principally to fish life). U. S. Department of Commerce, Bureau of Fisheries Bulletin 22.
5. Hart, W. B., P. Doudoroff, and J. Greenbank. 1945. Evaluation of Toxicity of Industrial Wastes, Chemicals and Other Substances to Freshwater Fishes. Water Control Laboratory, Atlantic Refining Company, Philadelphia, Pennsylvania.
6. Parsons, J. D., 1968. The Effects of Acid-Strip-Mine Effluents on the Ecology of a Stream. Arch. Hydrobiol. 65(1):25-50.
7. Rudolfs, W., et. al. 1953. Industrial Wastes. Reinhold Publishing Company, New York.

RADIOACTIVITY

I. GENERAL CONSIDERATIONS. There are at present no numerical radiological criteria directly applicable to the open waters of Lake Superior. Releases of radioactive materials to the lake (or otherwise) are regulated, however, by license by the Atomic Energy Commission.¹ Concentration of radionuclides in food and water used in interstate commerce, derived from the lake, are regulated by the U.S. Public Health Service. In addition, State and local regulations limit the concentrations permitted in public drinking waters.

The Federal Water Pollution Control Administration has been working with the Atomic Energy Commission and the U. S. Public Health Service to develop model radiological criteria for water. These criteria will apply to receiving waters, as different from waste effluents which are regulated by the Atomic Energy Commission as noted above. These criteria will be composed of three parts designed for the protection of human health as it may be affected through (1) drinking water, (2) waters used for recreation and other purposes involving potential human contact with or ingestion of water, and (3) waters used for the production or processing of food for human consumption (i. e. fish, shellfish, irrigated crops, milk, etc.).

After a draft of the criteria, developed at staff level through the joint effort of these three Federal agencies, has been reviewed and officially endorsed by each agency, it will be submitted to the Federal Radiation Council, the Conference of State Sanitary Engineers and an appropriate organization of the State radiological health officers for review, comments and hopefully, endorsement. This process may require up to a year to complete.

II. EXISTING CONDITIONS. The 12 year average gross beta radioactivity at Duluth is approximately 9.5 picocuries/l, including several years of active atmospheric bomb testing (and accompanying fallout). Radioactivity levels since 1965 have averaged less than 3.5 picocuries/l.

The similar 12 year average for total alpha activity, which includes radium and other naturally occurring radionuclides, is approximately 0.12 picocuries/l.

Similar averages were obtained at the St. Mary's River station.

III. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. It is recommended that action to establish radiological criteria for Lake Superior be deferred until the model criteria have been fully developed.

IV. REFERENCES.

1. U. S. Atomic Energy Commission, Part 20: Standards for Protection Against Radiation, Federal Register 25 (224): 10914-10924. November 17, 1960.
2. National Committee on Radiation Protection, Report of Ad Hoc Committee, Somatic Radiation Dose for General Population, Science 131:482. February 19, 1960.
3. Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposures. Handbook No. 69, National Bureau of Standards, Washington, D. C. 1959.
4. Background Material for the Development of Radiation Protection Standards. Staff Report, Federal Radiation Council, Washington, D. C. July 1964.
5. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C., April 1968.

ALL OTHER POLLUTANTS

I. GENERAL CONSIDERATIONS. Application factors provide a rational basis for estimating safe concentrations of pollutants utilizing easily obtained lethal values and are especially useful for establishing safe concentrations of mixed effluents. The procedures to be followed in deriving application factors are discussed on pages 58 and 59 of the Report of the National Technical Advisory Committee on Water Quality Criteria and a brief outline follows.

As the report points out, a great difference usually exists between the toxicant concentration that kills in a few days and the concentration that is just barely safe over one or more entire life cycle periods of continuous exposure to the toxicant. An application factor is composed of the ratio or fraction derived by relating, for a given pollutant, the mortality data from a four day toxicity test to the just safe concentration for the entire life cycle. This factor can subsequently be used to estimate environmental concentrations of this toxicant that are safe for different species of fish or in different water types. One does this by multiplying the application factor for the pollutant by the toxicity data obtained from a four day test with the new species or water type. A different application factor must be calculated for each pollutant.

Thus, application factors are important because they eliminate the necessity of having to expose entire life cycles of all species in all water types. They have varied from 1/7 to 1/500 for different pollutants that have been tested.

II. RECOMMENDED CRITERIA FOR LAKE SUPERIOR. In the absence of specific information, safe concentrations of pollutants should be:

1. For nonpersistent pollutants or those that have noncumulative effects, the environmental concentration should not exceed 1/10 of the 96-hour TL_m level at any time or place, and 90% of the measurements should not exceed 1/20 of the 96-hour TL_m value.
2. For other toxicants the environmental concentrations should not exceed 1/20 and 1/100 of the 96-hour TL_m level under the conditions described in (1) above.
3. Proportional reductions should be made in the permissible concentrations of pollutants when they are known to affect or add to the toxicity of other pollutants present in the water.

III. REFERENCES.

1. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C., April 1968.
2. Mount, D.I., and C. E. Stephan. 1967. A Method for Establishing Acceptable Toxicant Limits for Fish--malathion and the butoxyethanol ester of 2, 4-D. American Fish Society, Trans. 96(2): 185-193.

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MR. DOMINICK: If it is satisfactory with the conferees, we will proceed with the entire FWPCA statements and then make ourselves available to questions at the conclusion of those statements.

Is that satisfactory with the conferees?

Fine.

The next speaker will be Dr. Donald Baumgartner, who is an engineer and Chief of the National Coastal Pollution Research Program at the Pacific Northwest Water Laboratory in Corvallis, Oregon. He will comment on lake currents as presented on Pages 15 and 16 of the report and on Page 27.

Dr. Baumgartner.

MR. KLEIN: Dave, would you like to break at this point?

MR. DOMINICK: His statement will be 15 or 20 minutes.

MR. KLEIN: Let's make it and then notify everybody we will break at this time and come back at 1:30.

MR. DOMINICK: Fine.

We will plan to break the conference at the conclusion of this statement and reconvene here at 1:30.

Dr. Baumgartner.

(Applause.)

Dr. Donald J. Baumgartner

STATEMENT OF DR. DONALD J. BAUMGARTNER,
CHIEF, NATIONAL COASTAL POLLUTION
RESEARCH PROGRAM, FEDERAL WATER
POLLUTION CONTROL ADMINISTRATION,
PACIFIC NORTHWEST WATER LABORATORY,
CORVALLIS, OREGON

DR. BAUMGARTNER: Mr. Klein, Commissioner, conferees:
My name is Donald Baumgartner.

Mr presentation deals with the fate of solids discharged into Lake Superior with special emphasis on that discharged by Reserve Mining Company's operation near Silver Bay, Minnesota, because of the magnitude of this single discharge.

CHARACTERISTICS OF RECEIVING WATER

Studies of lake currents by the Federal Water Pollution Control Administration showed a net flow SW in the discharge area (Figure 1)*. In general, the patterns were similar to those found by Ruschmeyer and Olson years earlier (Figure 2). This shows the development of a circulation "cell" within the Duluth embayment, mixing with water in the main part of the lake, on a band drawn approximately north from the Apostle Islands. Near the surface the currents were quite high, averaging nearly 0.6 feet per second in the period May to October 1967, which near the bottom they averaged less than 0.2 feet per second. The bottom contour map of the lake shows a broad ridge (Figure 3) north of the Apostle Islands, separating deeper water on either side, a factor which contributes to the

* Figures were not entered as exhibits.

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circulation. In both summer and winter, circulation cells can be established in the vertical by temperature - associated density differences, as well as by topographic features. Figure 4, taken from Ruschmeyer and Olson's 1958 report¹, shows a series of summer temperature profiles at stations in the western lake which are representative of the type found when vertical circulation is segmented into cells by the abrupt changes in density. Waves, caused by wind and pressure differences, existing both on the surface of the lake and at the zone of abrupt density change, the thermocline, contribute in an extremely variable and important manner to mixing of the water mass and transport of pollutants.

CHARACTERISTICS OF DISCHARGE

The main waste streams are discharged from two laundries extending to within several hundred feet from the edge of the delta built up during the history of the operation. After leaving the confining structure of the laundries, the streams spread out, meander, and deposit the heavier portion of the solids, merging into essentially one stream before entering the lake. There the waste stream of 720 MGD (million gallons per day) is approximately 1/4 mile wide and 4 to 6 inches deep². According to a report by C. R. Collier of the Geological Survey³, nearly all the solids in the stream are less than

¹Ruschmeyer, O. R., and T. A. Olson, "Water Movements and Temperature of Western Lake Superior", U. of Minnesota School of Public Health, November 1958.

²Telecom Dr. Donald Mount, Director of the National Water Quality Laboratory, Duluth, Minnesota, 4-2169.

³C. R. Collier, Preliminary Report....., U. S. Geological Survey, Water Resources Division, St. Paul, Minnesota, November 1968.

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0.5 mm (millimeters) in diameter. Since about 60 percent by weight of the original waste stream is smaller than this size, I have estimated that 60 percent of the solids enter the lake.

The lake boundary at the discharge site is not the original natural shore, but consists of deposited tailings on a slope of .2, vertical to horizontal, to a depth of 650 feet.

CHARACTERISTICS OF DENSITY FLOWS

Because the waste stream which enters the lake has a density greater than ambient, I will describe briefly some of the general features of such flows. Through laboratory and field experiments, hydraulicians have observed that under certain flow conditions, fluids of different density can exhibit a great resistance to intermixing, due to the energy required to transfer fluid across the region of density difference. Even when the flow conditions within each stream are turbulent, the streams can maintain their spatial integrity over long distances and flow times. This situation is frequently observed in municipal water and sewage treatment plants where inflowing cold water sinks and flows across the bottom of settling tanks; in reservoirs, such as Lake Mead, where streams containing large amounts of dissolved and finely-divided solids flow toward the bottom; in coastal estuaries, such as the Mississippi and the Amazon Rivers, where the relative salt deficiency causes the streams to flow on top of the ocean water for great distances. The factor which is important in determining if this type of flow can exist is a combination of the relative velocity, the density difference, and a measure of the depth of flow. In many reservoirs the interfacial zone is fairly stable, whereas in lakes, such as

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Lake Michigan, the increased ratio of forces causes the interface to move in a periodic wave-like pattern. This would most likely be evident in Lake Superior in a time series of observations similar to those of Ruschmeyer and Olson I showed above. Under still further perturbation, the wave structure would become unstable, the interfacial resistance would be overcome, and the fluid streams would intermingle, rapidly losing their discrete identity. These three situations are shown schematically in Figures 5, a, b, c, respectively. Some attempts have been made to improve the application to shallow density streams by including a measure of turbulence within the stream as part of the stability factor calculation⁴.

DENSITY OF RESERVE WASTE STREAM

The fluid density of the Reserve waste stream applicable to this type of analysis is dominated by the concentration of fine suspended solids. Experience with lab and field studies has shown that under turbulent flow conditions, the fluid motions of such streams are similar to streams where the density is determined by the dissolved constituents.

While there is ample experimental evidence to support that 0.5mm particles will be transported over the delta, it may be stretching to assume that such particles contribute to the gross fluid density in the same way as much finer material. However, for purposes of this analysis, I have embraced this assumption, and using a standard method⁵ have calculated the density as 1.0084.

⁴Middleton, Gerald V., "Experiments on Density and Turbidity Currents, II. Uniform Flow of Density Currents." Canadian Journal of Earth Sciences, 3, 627-637, 1966.

⁵Fair, G. M. and J. C. Geyer. "Water Supply and Wastewater Disposal". Wiley and Sons, Inc., New York, 1954, 971 p.

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ANALYSIS OF DENSITY FLOW STABILITY

When the waste stream leaves the delta and enters the lake there is a localized mixing which most likely causes a reduction in velocity, an increase in the depth of the density flow, and some reduction of the density difference due to dilution. No measurements have been made on the flow conditions within the lake, and there is no precise analytical method for computing what the values of velocity and depth might be, so guided by laboratory hydraulic studies and previous similar efforts, notably that of the Russian, Goncharov⁶, I have estimated that the depth may increase to about 15 inches, thus reducing the velocity to 0.65 feet per second. Under these conditions the density interface would be unstable, thus mixing with the lake would be expected. In addition to this mixing, which would be in the vertical direction, the flow field, or the submerged plume as it is sometimes called, would spread out horizontally in a narrow fan-like form, where the heavier portions of the sediment load are deposited. On the edges of the plume where mixing is occurring, eddies or clouds are shed from the main stream, either to be carried away by currents in the ambient fluid, or returning by gravity to the mixing region.

I would like now to show a series of slides, Figures 6 through 10, demonstrating hydraulic model studies of density flows similar to Reserve's. A stream was conveyed in an open channel on a slope of .2 through the surface of a quiescent reservoir of fresh water measuring 1.5 by 1.5 by 25 feet. This was done to minimize the

⁶Goncharov, V. N. "Dynamics of Channel Flow", translated from the Russian by U. S. Department of Commerce, NB Standards, Institute for Applied Technology.

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turbulent mixing at the surface. After a sufficiently long time to allow the initial effects to subside, the nature of the unstable interface is apparent. Deeper in the reservoir, the perturbations are more noticeable and eddies can be observed. At a greater flow, where the turbulent motion is more similar to Reserve's, the instability is markedly increased. When the channel is positioned above the reservoir's surface, there is considerably more mixing for the lower flows, due to increased turbulence at the entrance. On this scale the mixing may appear rather insignificant, but scaled up by a factor of about 400 to more nearly represent natural conditions, the eddies would indeed be significant in size.

From these studies and theoretical considerations, I conclude that Reserve's discharge most likely results in an unstable density flow which spreads out and becomes diluted as it flows down the face of the delta, shedding clouds of finely-divided particulate matter periodically, under relatively quiescent and nonstratified conditions in the lake, ultimately leveling off near, or at the bottom.

Under conditions of temperature stratification and/or relatively turbulent currents in the lake, situations I did not attempt to model in the hydraulics lab, the plum might spread horizontally at some level considerably above the bottom and shed considerably more material in clouds.

DISTRIBUTION OF PARTICULATES IN THE LAKE

Even if the majority of flow reaches the bottom most of the time, there is little likelihood that all the particulate matter would settle. Turbulent fluctuations associated with mean current

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speeds reported by the Federal Water Pollution Control Administration are sufficient to maintain particles smaller than 0.1mm in a state of transport for large distances. I understand Mr. Collier will speak further on this point. There is some evidence in Collier's paper to substantiate and quantify this opinion in the form of a map showing the approximate distribution of taconite tailings within a zone approximately 8 x 18 miles on the bottom of the lake near the discharge site. I have calculated that this deposit contains approximately 20 million long tons of material, or 13 percent of the total tailings produced in the history of operation. If the delta contains about 45 percent of the total, this still leaves about 40 percent unaccounted for and presumably widely dispersed in the lake, or elsewhere on the bottom. To obtain some estimate of how this might be retained and accumulated in the lake waters, calculations have been heretofore restricted to extremely simplified models of lake mixing, such as that used by Rainey⁷ and shown schematically in Figure 11. In this model a distributed waste load of 6,900 tons per day (10 percent of total discharge) would cause an ultimate increase in suspended solids in the whole lake, in over 400 years, amounting to 37 parts per million (ppm).

This presents an unrealistically low estimate of the impact on water quality due to incomplete mixing of the Duluth Embayment with the rest of the lake and because of the poor vertical mixing during the winter and summer periods of stratification. I

⁷Rainey, Robert H., "Natural Displacement of Pollution from the Great Lakes", Science 155, pp. 1242-1243, March 10, 1967.

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have, therefore, used a more appropriate, but still simplified, model which has just been developed by our coastal pollution research program, shown schematically in Figure 12. The basin on the left represents the Duluth Embayment and comprises 120 cubic miles; the remaining volume in the lake, 2,900 cubic miles, taking up the right-hand portion. The upper portion of the embayment is about 25 percent of the total and represents the lack of vertical transfer due to 5 months of stratification during summer and winter. For 1 month between each season the embayment is assumed to mix vertically. The same type of stratification can be employed in the right-hand portion, but provides very little increase in precision. Mixing between the two basins is not well established, but may easily be 30 times the flushing rate due to the inflow of 2,000 cubic feet per second from the St. Louis River. This inflow is assumed to be restricted to the upper layer during periods of stratification. The 10 percent portion of Reserve's waste stream which does not settle out is assumed to be restricted to the lower level during periods of stratification. By comparison to Rainey's model, as shown in Figure 13, this approach shows an increase of suspended solids in the Duluth Embayment to over 37ppm (parts per million) in about 20 years. Great significance is not to be attached so much to the concentration, but to the relatively rapid rate at which the concentrations might be increasing.

SUMMARY

In summary, based on available technical data concerning the specific characteristics of Reserve Mining Company's discharge of taconite tailings near Silver Bay, Minnesota, on results of studies

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on the currents and sediments in the region, and on theoretical and experimental evidence regarding problems of a similar nature, I have concluded:

1. Reserve's discharge does not exist under conditions likely to result in a stable density flow.
2. Instability and turbulent conditions will cause clouds of turbid water to shear off from the density flow, which can then be transported with the currents in the lake.
3. The main portion of the density current will probably descend to the lake bottom, except that when a strong thermocline exists, a significantly large portion of the stream may be carried off into the lake near the thermocline.
4. The solids in the portion of the density stream which reach the bottom are not completely removed by sedimentation within the immediate vicinity of the plant, say 50 square miles. The fine particles remaining in suspension are subject to transport over large distances by weak currents near the bottom and subject to widespread vertical and horizontal distribution during periods of storm and/or customary spring and fall periods of vertical mixing.
5. The currents and topography of the lake are such that suspended solids concentrations would increase more rapidly in the Duluth Embayment than in the lake generally, and would always be somewhat higher than in the rest of the lake.

Mr. Chairman, that concludes my statement.

(Applause.)

MR. KLEIN: Thank you for a job well done.

Honorable John A. Blatnik

At this time we ask the conferees for comments or questions.

Mr. John Badalich?

MR. BADALICH: May we reserve that for after lunch?

MR. KLEIN: Mr. Thomas Frangos?

MR. FRANGOS: We reserve our comments until after lunch.

MR. KLEIN: Mr. Ralph Purdy?

MR. PURDY: We will wait until after lunch.

MR. KLEIN: Mr. Murray Stein?

MR. STEIN: I have no questions.

MR. KLEIN: Congressman Blatnik?

MR. BLATNIK: Just one question, Mr. Secretary.

As I understand this testimony, really, it was a splendid presentation of a very technical description, which we will have in this whole hearing, particularly on Lake Superior.

In the statement we have of the Federal Water Pollution Control Administration by David Dominick, who is here, the first three lines read as follows: "The Great Lakes Region of the Federal Water Pollution Control Administration has prepared a report" -- I am assuming this is the official public report, made public and made available to all interested parties, and I repeat now -- "has prepared a report for this conference to use in their consideration of what is needed to preserve the existing quality of water," etc., "in the Lake Superior Basin."

Reference was made in an earlier statement read by Mr. Voigt for Governor Warren Knowles of Wisconsin, which is already

Honorable John A. Blatnik

part of the proceedings of this conference, and I quote this reference, "This conference must also evaluate reports in the news media alleging that a Member of Congress has attempted to interfere with a Federal report identifying a major source of industrial pollution in Lake Superior."

We shall hear more on this later, but I think it is essentially wrong. Mr. Secretary, and we ask that this be clarified. I ask you for a brief comment at this point, Mr. Secretary. Do you or any of your administrators or officials under your jurisdiction, to your knowledge, know of any Federal report that has been suppressed?

MR. KLEIN: Congressman Blatnik, you give me a chance to lay the ghost to rest. This is the official report and the only official report of the Department of the Interior and was issued about a week ago. There has been no attempt at suppression by any Congressman or any other Federal official. There is in existence a report put out by an individual who used to be employed by the Department of the Interior shortly before he left and that is his report, despite the fact it bears the words "Department of the Interior." The Department of the Interior did not authorize it and is not bound by the report. The only report that was put out officially by the Department of the Interior is this one put out a week ago.

Thank you.

We will break for lunch. We will start promptly at 1:30 this afternoon.

(Whereupon, at 12:20 p.m. a recess was taken until 1:30 p.m.)

A. P. Bartsch

AFTERNOON SESSION

MR. DOMINICK: Ladies and gentlemen, we have to move along now. We have a good many witnesses to hear from.

I would like to begin now by calling on Dr. Bartsch, who is the Director of the Pacific Northwest Water Laboratory and has the national eutrophication research project. Dr. Bartsch will discuss some of the unique features on Lake Superior presented on Pages 21 and 22 in the Federal Water Pollution Control Administration report.

Dr. Bartsch, if you will suspend for a few minutes. We are awaiting the return of the State conferees. They will be here momentarily.

All right, I believe we have a quorum of the conferees here at the present time. Dr. Bartsch, we would be very happy to hear from you at the present time.

STATEMENT OF DR. A. P. BARTSCH,
DIRECTOR, PACIFIC NORTHWEST WATER
LABORATORY, FEDERAL WATER POLLUTION
CONTROL ADMINISTRATION, NORTHWEST REGION,
UNITED STATES DEPARTMENT OF THE INTERIOR

DR. BARTSCH: Thank you, Commissioner Dominick.
Conferees, ladies and gentlemen:

A. P. Bartsch

This is a statement on eutrophication -- or lake aging -- viewed in relation to Lake Superior. I can best introduce the subject by quoting from the April 1969 Federal Water Pollution Control Administration report "An Appraisal of Water Pollution in the Lake Superior Basin." Even though I am aware that Dale Bryson this morning read some of this to you, I hope you will bear with me if I go through some of it slowly again because I want it as background and an introduction of what I am going to say. Now I am going to quote from Page 21:

"Lakes may be classified according to their level of primary productivity. The productivity or 'fertility' of a lake depends on nutrients received from regional drainage, on the depth, plus other interrelated factors which affect the metabolism of the lake. A eutrophic lake is at one end of the classification series and on the other end is an oligotrophic lake. While there are a number of characteristics associated with oligotrophic lakes, in short they are still 'biologically young' and have changed little since the time of their formation.

"Lake Superior is an excellent example of an oligotrophic lake, having very clear, cold water and very few living organisms. The lake is an exceedingly young lake in terms of its biological aging processes. It is thousands of years behind the other Great Lakes considering only natural aging. The lake nearly resembles its pristine condition as created eons ago.

"Lake Superior is a delicate lake and therefore great caution must be exercised when weighing the potential dangers

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to its ecology. Increases normally considered insignificant or acceptable in most lakes will dramatically alter this lake, because even such small changes will represent a large percentage of change."

With this, then, as an introduction to the subject, I will discuss eutrophication as it appears to me to relate to Lake Superior.

THE PROBLEM OF EUTROPHICATION

Observations on Lake Superior date back before the turn of the century, but information is far from complete in aspects related to eutrophication. Recent studies of note are the valuable and continuing efforts of the School of Public Health of the University of Minnesota and studies by the Fish and Wildlife Service carried out during the 1950's. Together they form much of the basis for my remarks¹.

The prospect of eutrophication, a pressing concern in Lakes Erie, Michigan, and Ontario, needs consideration also in Lake Superior. In simplest terms, it is the aging process of waters, in which they become more fertile and acquire a greater capability to grow algae and other forms of living matter. In many lakes the algae become so numerous that they make the water green and interfere in many ways with its continued usefulness. They also create taste, odor, and treatment problems in water supplies. These are common objectionable and visible symptoms of eutrophication. In addition, there are other more subtle symptoms that sometimes would pass without being noted except by the trained investigator. Nevertheless,

¹See list of reports attached.

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such subtle changes are forewarning clues that slow-acting, long-range changes are taking place.

Changes to look for include: decrease in transparency of the water; increase in total dissolved solids, including especially nitrogen and phosphorus needed for growth of algae; loss of dissolved oxygen in the deeper layers, and changes in bottom-dwelling animals and microscopic plants. When eutrophication has not proceeded to an obvious and objectionable stage, such as it now has in Lake Erie, it becomes necessary to examine the combination of these more subtle clues to sense the existing state of affairs. Such clues have already raised a warning flag in Lake Michigan. In many other cases they likewise reveal a forecast of things to come. Fortunately for Lake Superior, only the slightest evidence of increasing fertility or other clues to eutrophication have so far made their appearance.

A principal factor that affects the rate of eutrophication is the extent to which nutrients needed by algae enter the body of water. Elements of most concern are phosphorus and nitrogen. Under natural conditions, unaffected by the affairs of Man, the input of nutrients from the watershed and in precipitation generally is low. Then the aging process usually proceeds at a slow rate. But the more thoroughly we study the eutrophication problem, the more acutely evident it becomes that in some cases even the natural rates of nutrient input will need to be curtailed. Cultural developments on the watershed, such as the establishment or growth of cities and cultivation or other disturbance of the land, accelerate nutrient input. It makes no difference where along the time scale such

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increasing human influence is brought to bear. The end result is always the same. The lake is brought more rapidly to a higher level of fertility and greater crops of algae and other plants are produced than under natural influences alone.

In the absence of definitive data only rough estimates can be made of present rates of nutrient input. It appears that the watershed, its people, and human activities now contribute annually about 3 million pounds of phosphorus and 31 million pounds of nitrogen. On an area basis this is much less than present inputs to Lake Michigan. The difference undoubtedly reflects the tremendous disparity in human populations tributary to the two lakes. This also implies that nutrient control will become increasingly important as the basin population grows.

It has been shown repeatedly that a lake's response to increasing nutrient input, as I have described, is not merely a theory. It is a historical fact repeated over and over again in every continent. This can be verified readily by reference to the well-known histories of the lakes at Madison, Wisconsin, to the south; Lake Washington, at Seattle, to the west; and in Europe, at Lake Lemman, Lake Zurich, Lake Lucerne, Lake Constance, and Lake Maggiore, to mention only a few. There are valid reasons to believe that unrestrained, creeping eutrophication could well be the most serious water quality problem we face in this and other nations of the world.

At this point I call attention to three analytical papers on the Great Lakes prepared by Dr. Alfred M. Beeton of the University of Wisconsin in Milwaukee. He was the first scientist, I believe,

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to perceive, assess, and describe clearly the responses of the Great Lakes to the eutrophying influences of human affairs in the watershed areas. He has made the point in admirable scientific fashion that large lakes are susceptible, a point of great importance to this occasion. I would like to propose that these papers that call attention to this matter be accepted as exhibits for the record of this Conference.

If this is acceptable, I will identify them.

MR. DOMINICK: That is acceptable and they will be accepted as exhibits of the conference.

MR. BARTSCH: The first paper is dated 1965. Its title is "Eutrophication of the St. Lawrence Great Lakes."

(The above-mentioned paper, reprinted from Limnology and Oceanography, Vol. 10, No. 2, April 1965, pp. 240-254, is on file FWPCA Headquarters, Washington, D. C., and the Regional Office, Chicago, Illinois.)

MR. BARTSCH: The second is dated 1966 and is entitled "Indices of Great Lakes Eutrophication."

(The above-mentioned paper, reprinted from Pub. 15, Great Lakes Research Division, the University of Michigan, 1966, is on file at FWPCA Headquarters and the Regional Office, Chicago, Illinois.)

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MR. BARTSCH: The third one is dated 1967, and the title is, "Changes in the Environment and Biota of the Great Lakes."

(The above-mentioned paper, published by the Center for Great Lakes Studies, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin, is on file at FWPCA Headquarters and the Regional Office, Chicago, Illinois.)

MR. BARTSCH: Mr. Chairman, I wish also to submit for the record another paper, "Changes in the Great Lakes and Present Status", by A. F. Bartsch and C. F. Powers. It deals with historic changes in trophic status of the Great Lakes in relation to population distribution. It also looks briefly to the future possibilities in relation to population growth and potential nutrient inputs. This is dated April 1969.

MR. DOMINICK: That will be accepted and made an exhibit.

(The above-mentioned paper, published by the U. S. Department of the Interior, Federal Water Pollution Control Administration, Northwest Region, Pacific Northwest Water Laboratory, Corvallis, Oregon, is on file at FWPCA Headquarters and the Regional Office, Chicago, Illinois.)

MR. BARTSCH: I turn next to the present conditions in Lake Superior. It has been said many times, and I am sure with great pride, that this is the most pristine of all the Great Lakes. In this sense it is unique, a quality it shares with Lake Baikal in

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far-off Siberia. The symptoms and clues I mentioned are not yet here. It has the highest transparency, the least total dissolved solids, and lowest conductivity. On the average, you can see a bright object in 33 feet of water, compared with 15 in Lake Erie. Compared further with Lake Erie, it has one-third the total dissolved solids, one-third as much calcium, one-sixth as much sulfate, one-twelfth as much chloride, and one-fifth as much sodium and potassium combined. One could consider using water of such mineral quality in the car battery or the household steam iron.

Lake Superior now grows little in the way of phytoplankton or free-floating algae. The crops are not obvious to the eye. It is the least productive of the five Great Lakes. In reflection of this, there is only about 1 pound of particulate organic matter in an acre-foot of the surface water, (upper 82 feet), compared with 7 to 10 in the western basin of Lake Erie. Bottom animal life at similar depths is much less than in Lake Huron or Lake Michigan.

Little is known about phosphorus levels and their distribution in the lake. The average concentration appears similar to Lake Michigan, at about 0.01 mg/l. This equals about two-fifths of an ounce mixed in an acre of water one foot deep. Such limited phosphorus levels, coupled with the observation¹ that at times 70 to 100 percent of it is already in the organic form, suggest that algal growth is limited by phosphorus deficiency. If this is true, it emphasizes even more the need for prompt curtailment of phosphorus input.

¹Putnam and Olson, Loc. cit. 1959, p. 28.

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These and other characteristics that could be stated reinforce the view that Lake Superior is early in the aging process. This means that since its formation by glacial action some 12,000 or more years ago Lake Superior has admirably withstood the pressures of time. The beginning wrinkles of age have hardly begun to show.

In the light of these circumstances some people might claim that its present pristine status is evidence that Lake Superior is immune to these natural influences -- that eutrophication could not become a serious problem. Several points of response need to be made.

First is the matter of size. Until recently most studies of eutrophication involved fairly small lakes. From the current state of knowledge one can expect that Lake Superior will differ from small lakes in the details of its response to the forces of eutrophication. But there is no doubt that even here these forces will in time produce undesirable change. That large lakes are not immune simply because they are large is already evident from happenings in other members of the Great Lakes. It just may take a longer time.

The second point relates to deterrence because the water is cool. Data covering a nine-year record show that the St. Mary's River, redirecting the output flow from Lake Superior, had a summer mean of 17° centigrade with average maxima reaching 20.4° centigrade. Along the south shore temperatures were similar and occasionally higher. Cool temperatures such as these may not favor production of especially undesirable blue green algae, but diatoms and other algae grow well under these conditions.

I have consulted on this question with a number of colleagues, including Professor Charles R. Goldman at the University of California at Davis. He has studied cold water lakes in the

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Antarctic and in Alaska. An Antarctic lake at Cape Evans, with temperature near the freezing point, had eutrophic characteristics. He has seen similar lakes in Alaska. Even Lake Tahoe in California, a high altitude lake with temperatures around 21 degrees centigrade, has sufficient production to be of concern. It also responds by increasing algal production when nutrient levels are increased. Temperatures between 18 degrees centigrade and 21 degrees centigrade are known to be optimal for some kinds of algae. This means, then, that there can be no relaxing simply because Lake Superior is cool.

The third point is that there is now a suggestion, at least, that Lake Superior does respond in customary fashion to the input of nutrients. Data are available from a 1958 preliminary investigation of nutrients in western Lake Superior by the School of Public Health on the University of Minnesota. Substantially higher levels of nitrogen and phosphorus were noted near Duluth and Superior than in other areas studied. It was also found that plankton chlorophyll was more abundant in this area -- reflecting a growth response to higher nutrient availability.

CONCLUSION

In conclusion, I wish to emphasize several points:

First -- there is no reason to believe that Lake Superior is in some peculiar way immune to the forces of eutrophication. Failure to take appropriate anti-eutrophication action will lead eventually to a less desirable Lake Superior. How long this will take is now unpredictable, but the rate will be greatly influenced by human activities in the watershed.

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Second, Lake Superior and Lake Michigan are the headwaters of the remaining Great Lakes. Whatever character this lake is permitted to acquire, it will have great impact on the success of protecting or restoring the lakes downstream.

Third, Lake Superior is said to have a self-purging rate estimated to be well in excess of 500 years. This means that it acts like a trap and any persistent nutrient such as phosphorus will tend to accumulate. It also means that if high levels are reached for all practical purposes they will remain so forever.

Fourth, it is noted the three States of the basin already have recognized the importance of phosphorus control in relation to eutrophication, and target dates have been set for phosphorus removal from municipal sewage at some of the lake's principal cities. This action is to be applauded.

Fifth, if there is pride in the uniqueness and splendor of Lake Superior, keep it that way. The first step is to limit nutrient input in every way possible. The second is to establish an appropriate monitoring program to be sure that plant nutrients do not creep above their present acceptable levels.

Thank you.

(Applause.)

LIST OF CITED REPORTS

Beeton, A. M., J. H. Johnson, and S. H. Smith. April 1959. "Lake Superior Limnological Data, 1951-1957." U. S. Fish and Wildlife Service Special Scientific Report--Fisheries No. 297. Washington, D. C. 177 p.

Putnam, H. D. and T. A. Olson. June 1959. "A Preliminary Investigation of Nutrients in Western Lake Superior, 1958-1959." University of Minnesota School of Public Health. 32 p., appendices.

Putnam, H. D. and T. A. Olson. June 1960. "An Investigation of Nutrients in Western Lake Superior." University of Minnesota School of Public Health. p. i-ii, 1-25, appendices.

MR. DOMINICK: Thank you, Dr. Bartsch. You bring with you a vast amount of experience and background to this subject. Your voice is one which carries great authority in this field. We thank you very much for coming.

MR. BARTSCH: Thank you, Commissioner.

MR. DOMINICK: The next speaker will be Dr. Robert Bunch, who is Chief of Biological Research at the Robert A. Taft Sanitary Engineering Center, in Cincinnati. He will present a statement for Dr. David G. Stephan, the Acting Assistant Commissioner for Research and Development. Dr. Stephan's statement presents findings of the research and development program discussed on Page 38 of the report as they relate to Recommendation No. 7. Dr. Stephan is expected to be here for any questioning which may come tomorrow.

Dr. Bunch.

MR. PURDY: Mr. Chairman, will a period be allowed for questioning on the statements made?

MR. DOMINICK: I am sorry, I didn't hear your question.

MR. PURDY: Will the conferees have an opportunity to ask questions of those who are presenting statements this afternoon?

MR. DOMINICK: They certainly will. If you wish, we could suspend at the close of each individual statement for any

A. F. Bartsch

questions which you may have.

Do you have any questions of Dr. Bartsch while he is here with us?

MR. PURDY: I do question the matter of the additional papers that are made a part of the record. Will these papers be made available to the conferees? Do they have a bearing on the information that was presented here so that the conferees can review these papers and consider the content in any decision that they may reach following this conference?

MR. DOMINICK: They will be made available to all conferees and certainly you will be given an opportunity to review them before any final recommendations are agreed upon.

MR. PURDY: Fine.

In addition, we would like to compliment Dr. Bartsch on his statement. Like the Lake Michigan statement, we find it is very well put together and is an excellent description of the existing situation.

MR. DOMINICK: Do any of the conferees have any questions for Dr. Bartsch at this time?

(No response.)

Dr. Bunch, you may proceed.

David G. Stephan

STATEMENT OF DAVID G. STEPHAN,
ACTING ASSISTANT COMMISSIONER,
RESEARCH AND DEVELOPMENT, FEDERAL
WATER POLLUTION CONTROL ADMINISTRATION,
U. S. DEPARTMENT OF THE INTERIOR,
(READ BY ROBERT BUNCH, CHIEF,
BIOLOGICAL RESEARCH, ROBERT A. TAFT
SANITARY ENGINEERING CENTER,
CINCINNATI, OHIO.)

DR. BUNCH: Dr. Stephan expresses his regret he cannot be here. I will present a portion of this statement, which will be part of the record, entitled "Current Status of Waste-Treatment Technology."

I appreciate this opportunity to discuss recent advances in the waste treatment field and the role of the Federal Water Pollution Control Administration in developing and applying new technology for the treatment of wastewaters.

The objective of the Federal Water Pollution Control Administration waste treatment research and development program is to develop and demonstrate the technology necessary to achieve, at lowest cost, any level of waste treatment which may be required to meet pollution control needs. The methods being developed range across the spectrum of physical, chemical and biological techniques. They range from the "ordinary," such as filtration and gravity

David G. Stephan

settling, through the "novel," such as biological denitrification to remove ammonia, to the "exotic," for example, reverse osmosis or ultrafiltration. Techniques are under study to improve the performance of existing primary treatment, to upgrade and extend the capability of conventional secondary treatment, as well as to develop and apply entirely new "tertiary treatment" methods.

There are actually two corollary objectives to be attained through improved waste treatment technology. The obvious one is the alleviation of the Nation's increasing water pollution problems through removal of pollutants from waste effluents. The other is the renovation of wastewaters for deliberate reuse as industrial, agricultural, recreational, or in some cases, even municipal supplies. In point of fact, these two objectives cannot really be separated for as our ability to cleanse wastewaters increases the resulting product water approaches nearer and nearer to or may even exceed the quality of a water supply. This concept, perhaps startling to the average citizen, will nonetheless play a larger and larger role in water resource management, especially in water-short areas.

The Federal Government program to develop and demonstrate advanced waste treatment and wastewater renovation methods was initiated in 1961. During the 8 years of this program some \$25 million have been invested in research and development on new waste treatment technology. Within the last 2 or 3 years the fruits of this program have become apparent with the emergence of several advanced waste treatment (AWT) systems into the demonstration plant phase.

David G. Stephan

The Federal Water Pollution Control Administration research and development program on advanced waste treatment technology is centered at our laboratory in Cincinnati, Ohio. However, a task of this magnitude requires the talents of the best scientific and engineering minds in this field in the entire country, regardless of whether they are in government, in the universities, or in industry. Because of this, much of the work has been carried out through contract and grant projects from one end of this country to the other. Appendix A provides a summary picture of the status of process development and the locations at which this work has been or is being conducted.

(The Appendix referred to follows:)

APPENDIX A

SUMMARY OF ADVANCED WASTE TREATMENT PROCESS
DEVELOPMENT STATUS IN U. S.

<u>Treatment Process</u>	<u>Scale</u>	<u>Location</u>
Activated Sludge - Modified	100 mgd field evaluation being planned 750,000 gpd field evaluation being planned 3 mgd pilot plant being planned 300,000 gpd pilot plant in design stage Two 100,000 gpd pilot plants in design stage 75,000 gpd pilot plant in design stage 14,000 gpd pilot plant in design stage	Los Angeles, Calif. Dallas, Tex. Chino, Calif. Irvine, Calif. Washington, D. C. San Buenaventura, Calif. Massau County, L.I., N.Y.
Absorption-Granular Activated Carbon	7.5 mgd demonstration plant under construction 5.0 mgd demonstration plant in design stage 750,000 gpd field evaluation plant in design stage 500,000 gpd pilot plant near completion 300,000 gpd pilot plant in operation 150,000 gpd pilot plant in design stage 100,000 gpd pilot plant in design stage 75,000 gpd pilot plant in operation 50,000 gpd pilot plant in operation 15,000 gpd pilot plant in operation 14,000 gpd pilot plant studies underway	So. Lake Tahoe, Calif. Piscataway, Md. E. Chicago, Ind. Massau County, L.I., N.Y. Pomona, Calif. Hemet, Calif. Santee, Calif. Lebanon, Ohio Washington, D. C. Ely, Minn. Massau County, L.I., N.Y.
Absorption-Fluidized Carbon Beds	7,000 gpd pilot plant in design stage	Trenton, N.J.
Absorption-Powdered Activated Carbon	15,000 gpd pilot plant in operation 15,000 gpd pilot plant in design stage	Lebanon, Ohio Roanoke, Va.
Absorption-on Inorganics	Rejected*	
Absorption-on Coal	15 gpd bench-scale studies completed Laboratory studies completed	Cleveland, Ohio Pittsburgh, Pa.
Absorption-on Polymers	Rejected*	

Treatment Process

Scale

Location

Ammonia Stripping

7.5 mgd demonstration plant under construction
200,000 gpd pilot plant in design stage
100,000 gpd pilot plant in design stage

So. Lake Tahoe, Calif.
Prince Wm. County, Va.
Washington, D. C.

Bio-denitrification-tank

2 mgd field evaluation plant in design stage
200,000 gpd pilot plant in design stage
100,000 gpd pilot plant in design stage
100 gpd bench-scale unit in operation

Santee, Calif.
Prince Wm. County, Va.
Washington, D. C.
Cincinnati, Ohio

Bio-denitrification-column

300,000 gpd pilot plant in design stage
800 gpd bench-scale studies underway

Irvine, Calif.
Pomona, Calif.

Bio-nitrification

300,000 gpd pilot plant in design stage
200,000 gpd pilot plant in design stage
100,000 gpd pilot plant in design stage
100 gpd bench-scale studies in operation

Irvine, Calif.
Prince Wm. County, Va.
Washington, D. C.
Cincinnati, Ohio

Biological Phosphate Removal

23 mgd field evaluation completed
3 mgd pilot plant being planned
300,000 gpd pilot plant in design stage
100,000 gpd pilot plant in design stage
100,000 gpd pilot plant in design stage
Laboratory scale studies underway

San Antonio, Tex.
Chino, Calif.
Irvine, Calif.
Detroit, Mich.
Washington, D. C.
Ada, Okla.

Biomass Treatment

300,000 gpd pilot plant studies completed

Lawrence, Calif.

Combined Chem-biological Treatment

Bench-scale studies completed

Tucson, Ariz.

Congulnation-Inorganic

7.5 mgd demonstration plant under construction
5.0 mgd demonstration plant in design stage
2 mgd field evaluation plant in design stage
750,000 gpd field evaluation plant in design stage
500,000 gpd field evaluation plant in design stage
500,000 gpd pilot plant under construction
300,000 gpd pilot plant being planned
150,000 gpd pilot plant planned
150,000 gpd pilot plant in design stage

So. Lake Tahoe, Calif.
Piscataway, N.J.
Santee, Calif.
E. Chicago, Ind.
Lawrence, Calif.
Nassau County, L.I., N.Y.
Irvine, Calif.
Dallas, Tex.
Hemet, Calif.

<u>Treatment Process</u>	<u>Scale</u>	<u>Location</u>
<u>Coagulation-Inorganic (Cont'd)</u>	100,000 gpd pilot plant under construction	Detroit, Mich.
	100,000 gpd pilot plant in operation	Washington, D.C.
	75,000 gpd pilot plant in operation	Lebanon, Ohio
	70,000 gpd pilot plant studies completed	Lancaster, Calif.
	15,000 gpd pilot plant in operation	Stanford, Calif.
	15,000 gpd pilot plant in operation	Ely, Minn.
	14,000 gpd pilot plant in design stage	Nassau County, L.I., N.Y.
	7,000 gpd pilot plant in operation	Pomona, Calif.
	200 mgd field evaluation study underway	Washington, D.C.
	120 mgd field evaluation study underway	Cleveland, Ohio
<u>Coagulation-Organic Polyelectrolyte</u>	10 mgd field evaluation study under design	So. St. Paul, Minn.
	100,000 gpd pilot plant in design stage	Washington, D.C.
	7.5 mgd demonstration plant under construction	So. Lake Tahoe, Calif.
	5.0 mgd demonstration plant in design stage	Piscataway, Md.
<u>Disinfection</u>	2 mgd field evaluation plant in design stage	Santee, Calif.
	500,000 gpd field evaluation plant in design stage	Lancaster, Calif.
	3 mgd pilot plant being planned	Chino, Calif.
	500,000 gpd pilot plant near completion	Nassau County, L.I., N.Y.
	500,000 gpd pilot plant in operation	Pomona, Calif.
	300,000 gpd pilot plant in design stage	Irvine, Calif.
	75,000 gpd pilot plant studies planned	Lebanon, Ohio
	60,000 gpd pilot plant in design stage	Hemet, Calif.
	50,000 gpd pilot plant in design stage	Washington, L. C.
	Two 50,000 gpd pilot plants in design stage	Santee, Calif.
<u>Distillation</u>	1,000 gpd pilot plant studies completed	Waterford, Conn.
	Laboratory studies completed	Cincinnati, Ohio
<u>Electrochemical Degradation</u>	Rejected*	
	75,000 gpd pilot plant in operation	Lebanon, Ohio
<u>Electrodialysis</u>	50,000 gpd pilot plant planned	Santee, Calif.
	7,000 gpd pilot plant studies completed	Orange County, Calif.
	7,000 gpd pilot plant in operation	Pomona, Calif.
	50 gpd bench-scale studies underway	Cambridge, Mass.

<u>Treatment Process</u>	<u>Scale</u>	<u>Location</u>
Electrolysis	Laboratory studies completed	Philadelphia, Pa.
Emulsion Separation	Rejected*	
Eutectic Freezing	Rejected*	
Extraction of Contaminants	Rejected*	
Extraction of Water	Rejected*	
Filtration - Coal	240,000 gpd pilot plant under construction	Cleveland, Ohio
Filtration - Diatomaceous Earth	250,000 gpd pilot plant studies in progress	Pomona, Calif.
	150,000 gpd pilot plant in design stage	Hemet, Calif.
	75,000 gpd pilot plant studies completed	Pomona, Calif.
	70,000 gpd pilot plant studies completed	Lebanon, Ohio
	15,000 gpd pilot plant in operation	Stanford, Calif.
	4,000 gpd pilot plant studies completed	Lancaster, Calif.
Filtration - Rapid Sand and Multi-Media	7.5 mgd demonstration plant under construction	So. Lake Tahoe, Calif.
	5.0 mgd demonstration plant in design stage	Piscataway, Md.
	2 mgd field evaluation plant in design stage	Santee, Calif.
	750,000 gpd field evaluation plant in design stage	E. Chicago, Ind.
	500,000 gpd field evaluation plant in design stage	Lancaster, Calif.
	500,000 gpd pilot plant in design stage	Nassau County, L.I., N.Y.
	300,000 gpd pilot plant in design stage	Irvine, Calif.
	150,000 gpd pilot plant in design stage	Dallas, Tex.
	150,000 gpd pilot plant in design stage	Hemet, Calif.
	100,000 gpd pilot plant in operation	Washington, D. C.
	75,000 gpd pilot plant in operation	Lebanon, Ohio
	35,000 gpd pilot plant study completed	Lancaster, Calif.
	30,000 gpd pilot plant study completed	Lancaster, Calif.
	15,000 gpd pilot plant in operation	Stanford, Calif.
	14,000 gpd pilot plant studies ready to start	Nassau County, L.I., N.Y.
	5,000 gpd pilot plant studies completed	Lebanon, Ohio

<u>Treatment Process</u>	<u>Scale</u>	<u>Location</u>
Flotation	1.0 mgd pilot plant under construction 300,000 gpd pilot plant in design stage 100,000 gpd pilot plant in design stage 50,000 gpd pilot plant studies completed	Prince Wm. County, Va. Irvine, Calif. Washington, D. C. Lancaster, Calif.
Foam Harvesting	Rejected*	
Foam Separation - Simple	500,000 gpd pilot plant studies completed 10 gpd bench-scale studies completed 10 gpd bench-scale studies completed	Pomona, Calif. Long Island City, N.Y. Linden, N.J.
Foam Separation - with Additives	15,000 gpd pilot plant in design stage 10 gpd bench-scale studies completed	San Jose, Calif. Long Island City, N.Y.
Freezing	Rejected*	
Hydration	Rejected*	
Ion Exchange	15,000 gpd pilot plant in operation 15,000 gpd pilot plant in operation 12,000 gpd pilot plant in design stage 3,000 gpd pilot plant in operation	Ely, Minn. Stanford, Calif. Santee, Calif. Pomona, Calif.
Ion Exchange - Removal of Organics	Bench-scale studies in progress	Berkeley, Calif.
Micorscreening	75,000 gpd pilot plant studies completed	Lebanon, Ohio
Oxidation - by Catalytic Autoxidation	Laboratory tests ready to start	Paramus, N. J.
Oxidation - by H_2O_2	Rejected*	
Oxidation - Light Catalyzed Chlorine Oxidation	Laboratory studies underway	Kansas City, Kan.
Oxidation - by O_3	240 gpd bench-scale studies underway	Murray Hill, N. J.

<u>Treatment Process</u>	<u>Scale</u>	<u>Location</u>
<u>Oxidation - by Corona Discharge</u>	Rejected*	
<u>Oxidation - by Autoxidation</u>	Rejected*	
<u>Phosphate Removal - through Mineral Addition</u>	1 mgd field evaluation completed 1 mgd field evaluation completed 100,000 gpd pilot plant in design stage 200 gpd bench-scale studies in progress 100 gpd laboratory scale studies completed	Washington Ct. House, Ohio Xenia, Ohio Washington, D.C. Cincinnati, Ohio Cincinnati, Ohio
<u>Reverse Osmosis</u>	Five 10,000 gpd pilot plants in design stage 5,000 gpd pilot plant in operation 4,000 gpd pilot plant in operation 3,000 gpd pilot plant in design stage 75,000 gpd pilot plant in design stage	Hemet, Calif. Pomona, Calif. Pomona, Calif. Lebanon, Ohio San Buenaventura, Calif.
<u>Trickling Filter</u>		
<u>Disposal Processes</u>		
<u>Adsorbate Incineration</u>	Carbon regeneration for 7.5 mgd plant under construction Carbon regeneration for 5 mgd plant in design stage Carbon regeneration for 2.5 mgd plant in operation Carbon regeneration for 750,000 gpd plant in design stage Carbon regeneration for 500,000 gpd plant under construction Carbon regeneration for 300,000 gpd plant in operation Exploratory studies--desk top	So. Lake Tahoe, Calif. Piscataway, Md. So. Lake Tahoe, Calif. E. Chicago, Ind. Massau County, L.I., N.Y. Pomona, Calif.
<u>By-product Recovery</u>		

Treatment ProcessScaleLocationDisposal Processes (Cont'd.)

Coagulant Regeneration	Line recovery for 7.5 mgd plant under construction Coagulant recovery for 5 mgd plant in design stage Pilot scale studies underway Pilot scale studies underway Bench-scale studies underway	So. Lake Tahoe, Calif. Piscataway, Md. Washington, D.C. So. Lake Tahoe, Calif. Cincinnati, Ohio
Foam Recycle	Exploratory studies - Laboratory tests completed	
Incineration	Pilot scale studies planned	Washington, D.C.
Injection	Exploratory studies--desk top	
Nuclear Cavities	Exploratory studies--desk top	
Excavated Cavities	Rejected*	
Ocean Dumping	Exploratory studies--desk top	
Pipelining	Field evaluation installation in design stage Pilot studies in design stage Bench-scale studies completed	Morgantown, W. Va. Chicago, Ill. Cleveland, Ohio
Sludge Centrifugation	Pilot plant in design stage Pilot plant in design stage	Irvine, Calif. Washington, D. C.
Sludge Filtration	Pilot scale studies in operation	Washington, D.C.
Sludge Hydrolysis	Exploratory studies--desk top	
Surface Spreading	Full-scale operation in progress Field evaluation unit in design stage Field evaluation unit in design stage	Canton, Ohio Morgantown, W. Va. Chicago, Ill.

Treatment Process

Disposal Processes (Cont'd.)

Wet Oxidation

Scale

Full-scale operation in progress
Full-scale operation in progress
Full-scale operation in progress
Full-scale operation in progress
Field evaluation studies planned
Experimental unit in operation

Location

Chicago, Ill.
Wheeling, W. Va.
Wausau, Wisc.
Rye, N.Y.
Santee, Calif.
Rothschild, Wisc.

Rejected: "Rejected" could be reconsidered on basis of new information.

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This effort has, in turn, stimulated private industry to enter this field to a most heartening degree. Chemical manufacturers, equipment fabricators, consultants, even the aerospace industry have responded to this challenge. As a result, the technology available today is not just one-of-a-kind and custom-built for experimental purposes. Believe me, a host of private firms stand ready to take orders for planning and design studies, for construction, and for equipment, chemicals, etc. At a 2-day Phosphate Removal Workshop we held last June in Chicago, for example, over a dozen companies presented their own treatment techniques for removing phosphorus from wastewater.

One of the most productive mechanisms we have utilized in our own process development work has involved the establishment of cooperative projects with various municipalities. At the present time, for example, we have a large variety of AWT pilot plants in actual operation at joint Federal-local field sites in Lebanon, Ohio, Pomona, California, and in Washington, D. C. Such joint projects give us the practical experience and firsthand knowledge required to bring research out of its ivory tower and into the hard realities of design, operational and maintenance problems and to measure our successes (and our failures) in terms of that universal index, dollars.

In this light, I would like to discuss tertiary treatment by describing our AWT pilot plant system at the District of Columbia Blue Plains Water Pollution Control Plant. Comparisons and costs will then be presented between primary, secondary and tertiary treatment systems.

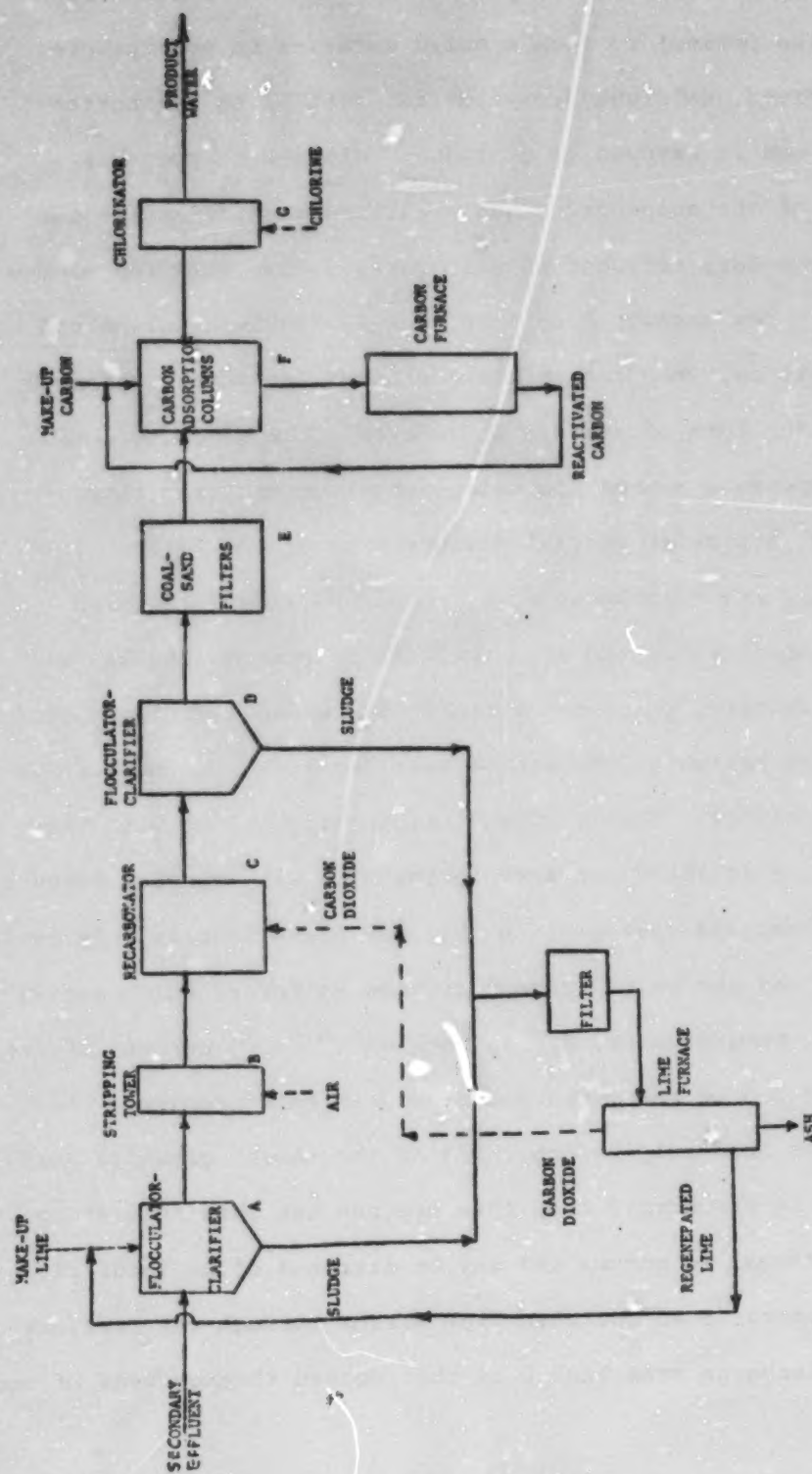
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Fundamentally, the pilot plant at Blue Plains consists of three steps, each designed to accomplish specific objectives in upgrading the quality of the Blue Plains secondary effluent. The first step, treatment with chemicals, is used to remove nutrients. The step, filtration through beds of sand and coal, removes any remaining suspended solids or particulate matter. The third step is treatment with activated carbon. This substance, made by "activating" fine particles of coal or other organic materials at high temperatures, is the type of material used in gas masks or even in some filter cigarettes to absorb or collect organic molecules. Used in a waste treatment system, this active carbon removes the dissolved biodegradable organics (BOD) and other organic molecules which have passed untouched through the entire previous treatment train. As a result of this 3-step treatment, the 50,000 gallons-per-day pilot plant can produce sparkling clear product water which, when disinfected with a small dose of chlorine, approaches very closely to drinking water in quality.

The complete tertiary treatment system is illustrated in Figure 1.

(Figure 1 follows.)

FIGURE 1
COMPLETE TERTIARY TREATMENT SYSTEM



David G. Stephan

Ordinary lime (calcium hydroxide) is added in the first tank, A. This lime makes the water highly alkaline and also reacts with the phosphorus present to form a solid material or precipitate. The solid formed, calciumhydroxyapatite, settles to the bottom of the tank and is removed as a sludge. Along with the phosphorus much of the suspended organic particulate matter present in normal secondary effluent is also carried down with the sludge and removed. The product from this tank is highly alkaline and in this condition, when air is blown through the water in Tank B, nitrogen in the form of ammonia is removed. The alkaline condition also imposes a severe biological shock on bacteria thus also serving to provide partial disinfection of the water. In the next tank, the recarbonator, C, carbon dioxide is bubbled through the water to soften it as well as to remove alkalinity. Another precipitate, calcium carbonate, is formed. This material settles to the bottom of the second settling tank, D, where it is removed as a sludge. This sludge, incidentally, along with that from Tank A, is filtered and then incinerated in a special furnace in the "lime recycle system." In this way fresh lime is regenerated for reuse in the system and carbon dioxide is formed which serves to supply the recarbonator, C. As much as 60 to 70 percent of the lime required can be recovered and reused in this process. Thus, lime purchases need only be about 1/3 of the amount actually used. Some dry ash is discharged from this process but this is sterile and nonpollutional in nature and may be disposed of as landfill.

Returning to the main flow stream through the tertiary plant, the discharge from Tank D is then passed through beds of coal

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and sand, E, very much as utilized in existing water treatment plants. In this step the very fine, nonsettling particles are filtered from the water producing a clear effluent ready for the activated carbon adsorption columns, F. The active carbon removes essentially all of the dissolved organic residues in the water and, frankly, produces a water so clean that a BOD measurement cannot accurately be made. The activated carbon, of course, becomes gradually saturated with these organics and periodically the carbon is removed from the contact tanks and "reactivated" in a furnace. This reactivation burns the collected organic materials to carbon dioxide and water and the rejuvenated carbon is reinstalled back in the process and reused. The product water from the carbon columns, F, is of quite high quality and, as a final step, is disinfected with a conventional chlorinator, G.

Next, let me refer you to Table I to illustrate the pollutant removals nominally achieved through each step of a primary-secondary-tertiary waste treatment system as described above.

(Table I follows.)

TABLE I

Removal of pollutants through primary-secondary-tertiary treatment system

Pollutant	Primary Sedimentation	Activated Sludge	Treatment step:			Activated Carbon Adsorption	Chlori- nation	Total Removal
			Precipitation- Stripping	Filtration	Adsorption			
Biodegradable organics (BOD)	35%	90%	94%	95%	99%	-	-	99%
Total organics (COD)	30%	80%	88%	90%	98%	-	-	98%
Suspended solids	35%	90%	95%	99%	-	-	-	99%
Phosphorus	10%	30%	95%	99%	-	-	-	99%
Nitrogen	15%	50%	90%	-	-	-	-	90%
Coliform bacteria	60%	95%	98%	99%	-	-	99.99%	99.99%

David G. Stephan

Note that conventional primary-secondary treatment as now commonly practiced will remove about 90 percent of both the BOD and the suspended solids, about 80 percent of the total organics present, about 30 percent of the phosphorus, 50 percent of the nitrogen and some 95 percent of the coliform bacteria. The chemical treatment step of a tertiary treatment plant will increase removal of each of these pollutants quite significantly. The filtration step also contributes to additional removals of each pollutant except nitrogen. Activated carbon adsorption effectively eliminates all the remaining BOD and almost all of the total organics; a relatively low dose of chlorine provides for disinfection to 99.99 percent or more.

While these improvements in percent removals are impressive enough in and of themselves, the impact on pollutorial loads discharged to a stream is even more dramatic. Remember that an increase in removal efficiency from 90 to 95 percent reduces the amount of pollution actually entering the stream by a factor of 2. An increase from 90 to 99 percent reduces the pollutorial load by a factor of 10!

For your interest, primary effluent may be considered to provide partial pollution control but no direct reuse of the effluent is possible. Activated sludge effluent achieves "conventional" pollution control; the effluent may occasionally be reused for rough industrial purposes or for nonfood crop irrigation in arid areas. The effluent from the chemical treatment step contains only a little more than half of the BOD load from an activated sludge plant, only half the troublesome suspended solids and coliform bacteria, and is highly treated for the nutrient elements, phosphorous and nitrogen. Such an effluent achieves much improved pollution control and, with disinfection,

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the effluent could be reused as a general irrigation supply, as a low quality industrial water for process or cooling purposes, and even for non-body contact recreation. With filtration, the water becomes suitable for a broad range of industrial purposes and with activated carbon adsorption treatment, we have achieved complete organic pollution control and the product water is really of high enough quality for any irrigation purpose, for essentially any industrial requirement and even for body contact recreation.

The next question to be raised is a natural: What will such treatment facilities cost to build and to operate? Table II summarizes projected full-scale costs for a typical municipal waste treatment plant in terms of 1969 dollars.

(Table II follows.)

TABLE II

Projected costs for a 100 mgd primary-secondary-tertiary treatment system
(1969 dollars)

<u>Treatment Step</u>	<u>Capital Cost (million\$)</u>		<u>Operating & Maintenance Cost (cents/1000 gal.)</u>	
	<u>Each Process</u>	<u>Cumulative</u>	<u>Each Process</u>	<u>Cumulative</u>
Primary Sedimentation	10	10	2	2
Activated Sludge	23	33	4	6
Chemical Precipitation- Stripping	14	47	6	12
Filtration	3	50	2	14
Activated Carbon Adsorption	12	62	5	19
Chlorination	1	63	1	20

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As seen, the addition of chemical treatment for nutrient removal will cost some \$14 million for a 100-mgd plant. This amounts to a 43 percent increased investment over that required for primary-secondary treatment facilities alone. Filtration for suspended solids removal would add another \$3 million or 7 percent to the prior costs. Activated carbon facilities will run another \$12 million and add 24 percent to the previous total, while chlorination facilities will require less than \$1 million and add less than 2 percent to the capital cost.

Typical operation and maintenance costs for large plants are also presented in Table II. As seen, the added operating cost for achieving nutrient removal with tertiary chemical treatment is about six cents per 1,000 gallons, which equals the cost of operating a present-day primary-secondary treatment plant alone. To add filtration raises the cost by an additional 2¢ per 1,000 gallons, while carbon adsorption will cost some 5¢ per 1,000 gallons more. The cost of chlorination is minimal and will add less than 1¢ per 1,000 gallons to the operating and maintenance costs of the system.

In one sense, the costs projected are certainly considerable. The capital investment for advanced waste treatment amounts to almost twice that for conventional practice. Operating costs are over three times those for operating today's plants! On the other hand, I suggest an analysis from another perspective. The additional capital investment calculates out to some \$37 or \$38 per individual served. Assuming a useful life of 20 years, this amounts to less than \$2 per year per person. With interest rates at, say, 6.5 percent, the cost per year per person is only about 1¢ per day. I might also ask that you compare this \$38 per capita capital investment with that for our gas,

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phone, and electric utilities. These amount to \$125, \$310, \$433, respectively.

As for operating cost, let's examine it in the same way. The 14¢ per 1,000 gallon figure associated with a complete AWT system beyond conventional treatment is less than 2¢ per person per day. To this let us add 1¢ per day figure given above for capital amortization. This 3¢ per day compares with an average per capita expenditure of 13¢ per day for gas, almost 22¢ per day for phone service, 26¢ per day for electricity for the community, 80¢ per day for food, and even 12¢ to 15¢ per day for cigarettes.

I conclude by submitting to you that the treatment technology now exists to effectively eliminate the sewerage municipal waste load to this Nation's lakes and streams and that the cost to do so is roughly only 1/4 of what we spend for cigarettes!

(Applause.)

MR. DOMINICK: Thank you, Dr. Bunch.

Do we have any questions from the conferees at this point?

MR. FRANGOS: Yes, Mr. Commissioner. I wonder if I could direct a question to Dr. Bunch.

Sir, on Page 7, Dr. Bunch, your cost is presented in terms of a 100 million gallons per day plant, and you talk about the cost of \$14 million to build the nutrient removal facilities. Could you give us an estimate of what this cost might be for a plant that would be 1/10 this size, let's say a 10 million per day plant, a rough estimate?

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DR. BUNCH: I don't have any figures here today. You can't divide by a hundred. The smaller a plant gets--

MR. FRANGOS: I suppose \$2 million for building a nutrient facility would be a fair guess at this stage, anyway?

DR. BUNCH: I would guess that, anyway.

MR. FRANGOS: Could we say the same thing about the operating costs? You indicated it would be about 6¢ per 1,000 gallons for a community that has a 100 million gallons per day plant. Could we maybe apply some factor to this, if you were going down to a 10 million gallon per day plant?

DR. BUNCH: I would assume that the operating cost itself would probably about double, if you are going down to a 1 million gallons per day plant.

MR. FRANGOS: I am sorry, 10 million gallons per day plant.

DR. BUNCH: I would say to that, add another 1/3 to that.

MR. FRANGOS: So we are talking about 9¢ or 10¢ per 1,000 gallons.

I am just trying to get another perspective on this thing we get at the State and municipal level. If we are talking about an operating cost of 10¢ per 1,000 gallons, how do you translate that into an annual cost? I think we can all do the arithmetic. I am trying to do it here.

DR. BUNCH: You mean your annual operating costs?

MR. FRANGOS: Yes. Ten cents per 1,000 gallons.

DR. BUNCH: This will depend on the yearly flow and also the size of the plant.

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MR. FRANGOS: Let's assume 10¢ per 1,000 gallons cost and a 10 million gallons per day plant.

DR. BUNCH: I do not have the figures yet, but they are available and they can be presented to the conference.

MR. FRANGOS: The only reason I raise the question is that if you look at it at cents per day per person, it doesn't appear very much. I am not suggesting that we don't make that kind of an investment, but it does present a real problem when it comes to budget time at the municipal level of government to translate that into thousands of dollars. What I am suggesting is that we do need to appreciate this as a fact of life, if we are to proceed in this direction, that we will need to have as much support as we can get in seeing these projects through to completion.

DR. BUNCH: I am sure that Dr. Stephan can bring these figures with him and we can give them tomorrow if you wish.

MR. FRANGOS: Thank you.

MR. DOMINICK: Are there any other questions?

Thank you, Dr. Bunch.

(Applause.)

MR. DOMINICK: Mr. Edwin Geldreich, who is a Research Microbiologist with the Bureau of Water Hygiene, which is discussed on Page 24 of the report, and Recommendation No. 6.

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STATEMENT OF EDWIN E. GELDREICH,
RESEARCH MICROBIOLOGIST, BUREAU
OF WATER HYGIENE, U. S. PUBLIC
HEALTH SERVICE, CINCINNATI, OHIO

MR. GELDREICH: Mr. Commissioner, conferees, ladies and gentlemen:

At this time I wish to present the following statement on the microbial considerations in the development of water quality objectives for Lake Superior.

The problem of microbial pollution to the Great Lakes Basin area ultimately relate to various contributions from polluted tributaries, harbors, and inshore areas contiguous to a particular lake. This fecal pollution is of varying magnitudes which may be derived from municipal sewage, storm water runoff, meat packing waste discharges, sugar beet processing, paper mill effluents, and agricultural practices.

Pathogenic organisms occur in polluted streams and lakes as a result of contamination by fecal discharges from warm-blooded animals, man included. The access of fecal pollution to water may add a variety of intestinal pathogens at any time, and at one time or another enteric pathogenic bacteria and viruses will be present. Many of these enteric pathogens that infect and multiply in the gastrointestinal tract of man are transmitted by the water route from fecal excretions of the sick and from carriers in the community. The

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most common genera of pathogenic bacteria found in water are Salmonella, Shigella, enteropathogenic Escherichia coli, Leptospira, and Mycobacterium. The enteric viruses consist of five subgroups which include polio viruses, infectious hepatitis virus, coxsackie viruses (Group A and B) ECHO viruses and adenoviruses.

In the Lake Erie drainage area, 180 Salmonella isolates representing 21 serotypes were recovered from a survey of 12 streams⁽¹⁾.

A similar study on the Raisin and Huron Rivers that empty into Lake Erie and the Saginaw River flowing into Lake Huron also revealed the occurrence of one or more Salmonella serotypes in 44 percent of the samples⁽²⁾. In another study a series of canals and rivers in the

Chicago area, which occasionally flow into Lake Michigan during heavy storm periods, were shown to contain Salmonella strains in 46 percent of samples and pathogenic enteroviruses in 27 percent stream samples^(3,4) so examined. Any tributary streams which carry a fecal pollution burden that is discharged into Lake Superior can also be expected to contain pathogens that are a risk to public health.

There is sufficient evidence from the literature to indicate pathogenic organisms can be present in the excreta of poultry, livestock, cats, dogs, and wild animals⁽⁵⁻⁸⁾. Such bacteria, which are equally pathogenic to man and other animals, may be acquired from contaminated food or water. Even freshwater fish may become actively infected with human pathogens after exposure to contaminated water and carry these organisms to clean stream recreational areas^(9,10).

Pathogenic Conveyance to the Tributary Streams and Lake Superior

Municipal sewage contains the major domestic input of human fecal discharges plus other domestic additions of laundry

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wastes and food refuse. In some cities wastes from meat packing and dairy plant operations may also be mixed in the domestic sewage collections. Salmonella and Shigella have frequently been detected (11-17) in sewage/. Raw wastes from institutions treating tuberculosis patients (18-21) will almost always contain large numbers of tubercle bacilli/. Sewage from four sanatoria showed from 425 to 10,000 tubercle bacilli per (18) 1 ml/. Municipal sewage containing wastes from dairies and slaughter houses may also be expected to discharge M. tuberculosis in their wastes.

Enteric viruses which are capable of producing diseases in humans are excreted by infected individuals into domestic sewage (22-25) in large quantities/. The peak incidence of isolation of enteric viruses in sewage occurs during the warmer months of the year/and (26) during periods of epidemic/, with fluctuations in the predominant type (27) being related to what is prevalent in the community at a give time/ (28,29) (30) Kelly and Sanderson/ found 15 strains of Cocksackie, ECHO, and polio- viruses present in raw sewage. Of 150 viruses isolated by Bloom, et al.,/from sewage samples, 31 were identified as ECHO viruses, four as (31) poliviruses, and 76 as Cocksackie. Many septic tank effluents have (32) been found to contain enteroviruses/. In one instance a septic tank effluent still contained viable poliovirus six months after a child from that home had contracted poliomyelites.

Untreated paper mill wastes introduce not only a high level of bacterial nutrients to the receiving stream, but also significant additions of fecal contamination which is intensified in magnitude by plant operational procedures. Fecal pollution may be

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introduced from poor quality stream water used for pre-process water, debarking and wood chipping operations, and chip washer water. Rodent contamination may occur on stored wood chips. Other sources of possible bacterial contamination are found from in-plant floor drainage and cross connection in-plant domestic sewage to the mill waste lines. Regrowth of this bacterial contamination has been observed to occur in the clarifier as a response to high levels of nutrients, pH below 8.0, and warm processing water temperatures. Fecal pollution found in paper mill wastes cannot be ignored. The implications are that enteric pathogens could also be present in such an environment. Stream sampling immediately below two paper reprocessing plants on a small tributary of the lower Raisin River were found to contain *Salmonella typhimurium* in February, *S. anatum* and *S. bredeney* in April, and *S. derby* in September.⁽²⁾

Pathogen Removal by Sewage Treatment

In a review of the literature on removal of pathogenic microorganisms by trickling filters, activated sludge, anaerobic digestion, and stabilization ponds, Kabler⁽³³⁾ concluded that these treatment processes will markedly reduce the number of pathogenic organisms present. However, the resulting effluents will contain a portion of each kind of microorganism originally present in the raw sewage. Those pathogenic bacteria, virus and parasites that do remain in the treated effluents constitute potential health hazards to persons using the receiving waters for recreational purposes. Where these waters are used as a source of raw water supply, any accidental break in treatment could quickly bring pathogens to our public water supply. Application of appropriate chlorination procedures

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to effluents from secondary treatment of sewage will further reduce the pathogenic bacterial populations to below demonstrable densities. Additional advanced waste treatment processes using chemical flocculation with sedimentation may be necessary in special problems involving reuse water for complete removal of parasitic ova and virus^(33,34).

Many factors are involved in sewage chlorination, including organic and ammonia residuals, effluent pH and temperature, chlorine contact time, uniformity of effluent-disinfectant mixing, and reliability of chlorine residual test, among others. Primary sewage effluents are more difficult to chlorinate to a specific coliform content than secondary effluent. Chlorination of primary effluents should not, under any circumstances, be considered a substitute for secondary treatment. The primary measurement for the adequacy of chlorine disinfection of treated sewage must be based on the coliform count since methods for detecting pathogens remain too complicated for routine monitoring purposes.

Pathogen Survival in Lake Superior

Microbial pollution entering Lake Superior from polluted tributaries and harbors will not immediately disperse by dilution nor rapidly decrease through death of the organisms. Instead, plumes of poor water quality will develop adjacent to those outlets into the lake. In these diffusion fields many of the bacteria and associated pathogens present will settle out by sedimentation into the water-sediment lake bottom interface. Our studies on bottom deposits from streams and lakes indicate *Salmonella* was isolated more frequently from mud than from the overlying water because of the concentration

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(35)

effect from fecal pollution "fall-out." Survival experiments on holding mud from a moderately polluted stream for seven days at 20 degrees centigrade suggested fecal coliform densities remain constant for two days, then begin a gradual decline. After ~~seven~~ days, their number was about 1/10 of the initial count. Salmonella derby declined at a slightly faster rate in these same experiments.

Lake Superior is a cold lake with water temperatures most frequently below 12 degrees centigrade. Under these conditions there will be a longer persistence of pathogenic bacteria in the bottom muds and in the lake water. While this time limit for pathogen survival is measured in terms of days, new fecal pollution is constantly being released to these mixing zones to counter-balance transient pathogen die-away by the forces of natural self-purification. During periods of storm water runoff and lake turbulence, bottom sediments from these mixing zones could be resuspended temporarily and spread by lake currents, carrying viable pathogenic microorganisms to new reaches of the lake.

Not all pollution organisms will necessarily be deposited at the lake bottom by sedimentation. Where portions of the lake contains particles of three microns size or smaller there can be an adsorption of microorganism to this material which is capable of remaining suspended in the water for a considerable time. Thus these finely divided particles moved by lake currents to a diffusion area of pollution can become a transport vehicle for microorganisms.

Taconite tailings of fine particle size could, in this way, bring some fecal pollution organisms into the areas of public

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water intake, given the proper set of circumstances.

Finally, if we are to conserve the excellent microbiological quality of Lake Superior water for the future, fecal pollution sources in affected tributaries and harbors must be controlled through adequate treatment.*

Thank you.

(Applause.)

MR. DOMINICK: Thank you, Mr. Geldreich.

Do we have any questions?

MR. VOGT: Mr. Chairman, I do. On Page 5 Mr. Geldreich refers to the difficulty of chlorinating primary sewage effluents.

I was wondering what you have in mind when you say "Primary sewage effluents are more difficult to chlorinate to a specific coliform content than secondary effluent."

MR. GELDREICH: This material has a definite demand for chlorine and varies greatly. There are many factors associated with the proper chlorination of sewage. We must remove the nutrients and we can best do this by secondary treatment and then chlorinate it. If we are to chlorinate primary effluents, I am concerned that we have just pushed the problem downstream; the nutrients are still there and we can go through the problem of regrowth of the organisms that may still remain in that primary effluent. You do not remove all the bacteria by primary treatment with chlorination. This is very difficult.

MR. VOGT: In your work have you ever done any studies of so-called split chlorination or prechlorination of primary treatment works?

*See attached references that were appended to original statement.

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MR. GELDREICH: I have not.

MR. VOGT: You are not familiar with what is published in the literature, then?

MR. GELDREICH: I have seen that, but this is not my speciality.

MR. VOGT: You made a judgment here.

MR. GELDREICH: Yes, sir, based on bacterial determinations.

MR. VOGT: But you are not familiar with the practice, then, I mean of pre-chlorinating raw sewage before primary treatment and then also post-chlorinating it?

MR. GELDREICH: I am aware of it.

MR. VOGT: Are you familiar with the results that can be obtained?

MR. GELDREICH: Oh, yes. Excellent results could be obtained if we have proper control of all these factors which I briefly mentioned a few of -- pH, contact time, etc. But our problem is, though you have at that point greatly reduced the bacterial content, we have not removed the nutrients which are still there in primary treated effluent, and we must be concerned downstream with these nutrients for they do separate the natural die-away of the organism from one stretch of the stream to the other.

MR. VOGT: I will just comment we have experienced very effective results of disinfection of sewage by chlorinating at primary treatment works, both pre and post, and then by bacteriological analyses of the effluent have demonstrated very effective removal of the test organism is accomplished.

MR. GELDREICH: I remember a few years ago I was up in

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your State in a conference with Mr. Purdy and I believe some of the other staff. We did discuss this problem. One of the things that we made a point of at that time that we are still concerned with is if there is a new entry of pollution this nutrient material becomes an excellent growth material downstream. True, we have removed the bacterial population if we have done the job properly, but we still have upset the natural die-away rate of that stream. If there is some reentry or some new entry of sewage down from it, the organisms are going to blossom out to aftergrowth phenomenon.

MR. VOGT: On page 3 you suggest that tuberculosis is spread by water supplies, is that correct?

MR. GELDREICH: Yes, sir. I cite the literature for that. There are several citations.

MR. VOGT: You cite that the tubercle bacilli have been found in sewage plant effluent, which I don't think is in debate.

MR. GELDREICH: Yes, sir.

MR. VOGT: But what happens? Is this inferring that possibly tuberculosis might be spread by drinking water? What is the significance of this?

MR. GELDREICH: Our concern is that these organisms, just like the coliform, will be reduced greatly by advanced waste treatment and can be eliminated by chlorination and secondary treatment. If they are not, we are concerned somewhere downstream they could enter into a recreational area, and we are concerned not only with what happens at the moment of discharge but we are concerned what happens when that water reaches either a water intake or recreational area downstream. Our concern, as you heard us many times state, we are interested in the concept of multiple barriers to prevent the

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possible hazards of pathogens getting into our drinking water.

MR. VOGT: I have one more question, Mr. Chairman.

In your next to the last paragraph where you refer to taconite tailings that might bring fecal organisms into the water supply of public works intakes, has your study indicated this has happened in Lake Superior?

MR. GELDREICH: We have some preliminary studies, they are actually being done by the Duluth National Water Quality Laboratory, and they have taken an entire pathogenic *ecoli* and have put this into the water which is in the lake in varying amounts of taconite tailings present and they find in their experiments that it is not toxic. The organisms not only survive, they also increase in their laboratory experiments. These are preliminary. They do increase at 4° centigrade, which is rather remarkable. I think this is a tremendous area where we must do more research. We must find the answers why this happens.

MR. VOGT: I don't think you answered my question. Are you saying that the taconite tailings could bring or do bring these organisms into the area of the public works?

MR. GELDREICH: Yes, sir, they could.

MR. VOGT: And do they? Have your studies indicated that this is occurring in Lake Superior?

MR. GELDREICH: Using a code form indicator -- and for years we have used this as an indicator of hazards in our work -- we find coliforms in this area of the water which is affected by taconite tailings. We therefore conclude if coliforms are there we conclude that pathogens are also there. But up to this point there has been no attempt to isolate particular pathogens from that particular water.

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MR. VOGT: Are these coliforms brought into the area of water intake by taconite tailings? Yes or no.

MR. GELDREICH: This is an area we must develop. It can come from some area near the taconite where it is released, but, more logically, as I have been trying to say here, it is very convenient for us to say it is a method of carrying these organisms if it floats into an area where there is pollution coming out from the tributary.

MR. DOMINICK: Are there any further questions?

MR. STEIN: Yes.

You know, Mr. Vogt raised the question on disinfecting of chlorinating primary effluent. Presumably this can be done satisfactorily in a laboratory. I wonder if any of you people with vast experience know whether on a 365-day-a-year basis, where they chlorinate primary effluent from a sewage treatment plant that is actually in the field this is satisfactory in killing the pathogens.

MR VOGT: I will answer that for you, Mr. Stein. Your question about chlorinating primary effluent, I think if I would answer it just the way you posed it there, probably the answer would be no, that you cannot do a satisfactory job. But that is not the method of choice for disinfection where only primary treatment is provided. At least the method of choice that we believe to be the most effective is to chlorinate the sewage, the raw sewage, as it comes to the primary sewage treatment plant so that the chlorine residual is maintained throughout the entire treatment process and then an additional shot of chlorine is added to the settled effluent

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to improve the disinfection. By this method of dual disinfection, you might call it, or we sometimes refer to it as split chlorination where chlorine is added to the raw and settled sewage, we have found that very effective disinfection is obtained.

MR. STEIN: Where is it done on a 365-day basis?

MR. VOGT: It is done 365 days in Michigan.

MR. STEIN: Where?

MR. VOGT: In some of our primary plants, where we do have primary treatment plants.

MR. DOMINICK: Fine. Thank you very much.

Are there any further questions?

We have with us today Thomas L. Kimball, the Executive Director of the National Wildlife Federation.

It has been brought to my attention that Mr. Kimball has to catch a plane back to Washington very shortly, so we will suspend with the FWPCA presentations at this time to hear from Thomas Kimball.

(Applause.)

STATEMENT OF THOMAS L. KIMBALL,
EXECUTIVE DIRECTOR, NATIONAL
WILDLIFE FEDERARATION, WASHINGTON, D. C.

MR. KIMBALL: Mr. Commissioner, conferees, and ladies and gentlemen:

I want to express my appreciation for the opportunity to appear before you today to share the concern of the National Wildlife Federation's 2-1/2 million supporters for the pollution problems

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facing one of our country's greatest aquatic resources, Lake Superior.

This concern is a logical reflection of the Federation's historic interest in water pollution abatement from support of the original Federal Water Pollution Control Act through the more recent and vital nondegradation policy of the Interior Department.

But in addition to bringing to you the spirit of my organization's concern, I want to briefly relate some pertinent findings of the Gallup Survey we recently commissioned to plumb the public's attitudes toward their natural surroundings.

In general, the survey found that 86 percent of the citizens in this country are concerned about the effects of air pollution, water pollution, soil erosion and wildlife destruction. Air and water pollution, in that order, were considered the most overwhelming environmental problems, and they were ranked so close together the difference isn't statistically significant.

In addition, the survey revealed that three out of four of our citizens said they would be willing to pay more taxes if the money could be earmarked to combat the deterioration of the natural environment. That should answer some of the questions raised before this conference as to whether or not the people would be willing to pay. And certainly, in my view, this conference has indicated, at least to this moment, that we have the technology to do much more than we are currently doing. I think this willingness on the part of the people to pay is quite significant. In the light of the current tax revolution and I would wager virtually every elective representative in Washington would agree that the public is generally disenchanted

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with the current tax structure -- a public declaration of willingness to pay more taxes is a revealing barometer of the public's desire to clean up the Nation's air and water.

Yes, the Federal Government has made a national commitment to cleaning up and preventing water pollution. The public has demonstrated its concern and willingness to support that commitment. And now the eyes of the Nation are focused on the Great Lakes -- immense bodies of freshwater of tremendous national importance for transportation, commerce, fish, wildlife and recreation -- and pollution problems of commensurate magnitude.

Lake Erie is a national, even international, disgrace. A testimony to an inane, cavalier attitude of our affluent society that has become an effluent society that is bearing bitter fruit.

Lake Michigan has its pollution problems, too: the municipal-industrial wastes of the Chicago-Gary-Harmond area; and, as I stand here, millions of tons of DDT are slowly climbing the lakes' ecological ladder to haunt, perhaps even terrify, us in the future.

In comparison, Lake Superior is as pure as a mountain brook. And our organization is dedicated to seeing that it stays that way.

One of the major problems at hand is the discharge of taconite tailings into the lake by the Reserve Mining Company. A review of the Interior Department report on the environmental impact of this waste disposal into the lake gives rise to deep concern for preserving the lake's claim to relative cleanliness.

Though you will hear them many times today, I'm sure, a number of the report's conclusions bear repeating:

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The total discharge of taconite tailings by the Reserve Mining Company in a 12-day period equals the annual sediment contribution to Lake Superior by all United States tributaries.

The original permits issued to the Reserve Mining Company permitted the dumping of tailings in a specified area of the lake. There is evidence, however, that much of the lighter, suspended materials are not deposited in the deep trough as intended, but move a considerable distance downshore with the lake currents. In fact, it is my understanding that some of these suspended particles are now appearing in the water supply system of the city of Duluth.

These suspended solids have been found at least 15 miles downshore from the place of deposition. This material has increased turbidity and undoubtedly has had a deleterious effect on bottom-dwelling organisms. The report also concluded the water quality criteria recommended by the Technical Advisory Committee for zinc, cadmium, and phosphorus for aquatic life production are being exceeded.

In my view, the report's most significant conclusion was that there are reasonable alternatives to dumping the taconite tailings into Lake Superior. The Bureau of Mines examined a stilling basin located approximately 5 miles from the Reserve plant and proposed it as a possible alternative waste disposal site. This area appeared the closest, and therefore the most economical, on-land disposal area available to the mining company.

The waste effluent would be pumped uphill to a settling basin and wastewater drawn off at a lower point for recycling and wash water. On a very preliminary basis, it was estimated that the capital investment in dike construction, pipeline, pumps and thickener

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would be approximately \$7.5 million for an initial capacity of 55 million tons of tailings (about 3 years' production). Average annual operating and dike rise cost would be \$3.3 million. Assuming a 10 year depreciation of the initial capital investment, plus the operating costs per year, the added unit cost would be roughly \$4 or 40¢ per ton or 3 percent of the value (\$12.80 per ton) of taconite and products.

There are those who will argue the point that we have no proof the pollution by the mining company has had any direct measurable effect on fish populations or that it poses any hazard to human health or to the lake's esthetic values. However, it is the hope of my organization that remedial action can be taken to abate pollution prior to the time that we have dead fish, health problems, or before it detracts from the aesthetic values of clean water.

I was very pleased to hear John Blatnik pledge his support to an action program to clean up pollution in this lake wherever it occurs, and I would like to add my voice to his and pledge the support of my organization, and I think we can speak for the citizens of this country that we want action now.

Although I have dealt at some length with the problem of taconite tailings pollution, this is not the only source of pollutants entering Lake Superior. The lake is also under attack by the residues of municipal, industrial, and agricultural activities.

But whatever the source, we must not delay in abatement. We have learned by painful experience that it is poor business to pollute now and pay later.

In the face of a national water crisis, we simply cannot afford to gamble with the quality of one of our largest bodies of

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freshwater.

Pollution abatement in Lake Superior, as in the rest of the United States, must be considered an integral part of doing business, and that is on the part of any industry. And, Mr. Chairman, let me assure you the eyes of the Nation are upon Lake Superior to see what pollution abatement and preventive actions are taken in view of the Federal Government national commitment to clean water, and the public's desire to see that commitment carried out.

To that end the National Wildlife Federation concurs with the general recommendations by the Interior Department which are aimed at maintaining Lake Superior's status as the cleanest of the Great Lakes:

"All municipalities should provide secondary treatment of wastes by January 1973" -- We have already heard that technology is at hand to preserve our clean water, to provide this type of treatment, and that it can be done at a nominal cost -- "and industries should provide an equivalent treatment by the same date."

Certainly if we can get this team of industry and municipalities to do the job we would be well on the way to the accomplishment of our goals.

"Continuous disinfection of all wastes should be provided by May 1970.

"Eighty percent of phosphorus, a substance which spurs the growth of algae, should be removed from wastes by January 1973.

"Combined sewers should be separated or pollution from this source controlled in some other manner by October 1977 to prevent

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contamination as a result of storm water overflow.

"Controls should be adopted to limit concentrations of a pesticides."

Let's not have a repetition in Superior of what has already happened in Lake Michigan. My understanding is if they never applied another ounce of DDT there, it would be some 20 years or more before the levels of those persistent chemicals are at least removed or at least turned downward in that particular lake, and no telling what will happen if they continue to apply it.

"Uniform rules and regulations should be enacted to control wastes from watercraft."

And finally:

"Dumping of polluted dredgings into the lake should be prohibited."

Mr. Commissioner, I heard in this meeting comments about a fact-finding conference. I read the Federal law and I read about conferences and I read about facts, and certainly this is one of the purposes of a conference. But I think the people will judge this conference by what actions are taken. If we find that we need additional facts, let's certainly collect them. But I, for one -- and here again I am sure I speak for the citizens at large -- am hopeful that we have sufficient facts now that some action can be taken on the facts that we have.

Let's get together with industry, with our municipalities, with agriculture, let's work out the problems. But if they won't do it willingly, then I think it is the responsibility of the people who

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are taxpayers to take whatever action is necessary to clean up the water. I hope, speaking as one citizen, that it will not be necessary for the citizens to take the kind of action that our governmental agencies won't. This means if we have to we will have to go to the other branches of Government, in this case the Judiciary, to see if the pollution abatement laws of this country are really being administered in the proper manner. And if the citizens are able to do it, where our executive agencies fail, in my view this would be a tremendous travesty of justice, it would be a terrible indictment, really, of our democratic system in this country. We have 86 percent of our citizens on an unbiased survey who have indicated their deep concern about the quality of our environment. They have indicated a willingness to pay the bill in order to accomplish the task, and what clearer mandate can the Executive agencies of our Government have to do the job of what it takes to maintain clean water.

Now, let's have Lake Superior for generations yet unborn in a condition that is clean so they can enjoy it as God made it, not like it looks after man got through with it.

Thank you.

(Applause.)

MR. DOMINICK: Thank you very much, Mr. Kimball, for a very constructive and informative statement. I think we all owe you and your Federation a great deal of thanks for the initiative which you took in commissioning the Gallup survey. That was a real public service -- an eye-opener to everyone who is concerned with pollution. We are grateful to you for coming and speaking in such a positive

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manner today.

MR. BADALICH: I believe Mr. Kimball has left the audience. But I, certainly, on behalf of Minnesota, appreciate his comments and I think they are very well founded, and I wish he could preach his remarks to the so-called municipalities and industries that were compelled to issue enforcement orders and studies etc. This would be a very good speech to give to each particular municipality, because we are faced with the problem of trying to comply with our orders. It seems money is a problem. But according to Mr. Kimball on the survey he conducted, this seemed to be a minimal task insofar as gaining public support. I wish this could be transmitted to him.

Secondly, a statement was made on Reserve Mining operations and we have invited Reserve Mining Company to appear as a witness for the State of Minnesota to explain their particular matter. I think the problem of the deposition of this material outside the lake area into the highly concentrated resort area, which is approximately 5 miles north of the plant, will be brought to light and explained. I wish Mr. Kimball could be here for this explanation. I am sure people realize this is not a problem that is very easily overcome.

MR. DOMINICK: We will hear now from Dr. Donald Mount, the Director of the Federal Water Pollution Control Administration National Water Quality Laboratory, here in Duluth. Dr. Mount will discuss some of the information discussed on Pages 27 and 28 of the report.

Dr. Mount.

(Applause.)

Donald I. Mount

STATEMENT OF DR. DONALD I. MOUNT,
DIRECTOR, NATIONAL WATER QUALITY
LABORATORY, FEDERAL WATER POLLUTION
CONTROL ADMINISTRATION, DULUTH,
MINNESOTA

ACCOMPANIED BY R. W. ANDREW,
RESEARCH CHEMIST, NATIONAL WATER
QUALITY LABORATORY, FEDERAL WATER
POLLUTION CONTROL ADMINISTRATION,
DULUTH, MINNESOTA

DR. MOUNT: Mr. Chairman, conferees, ladies and gentlemen:

The question of tailings distribution in Lake Superior has been the subject of considerable discussion during recent years. In a report entitled "Report on Tests for Taconite Residuals in Lake Superior 1957 and 1958," by the Minnesota Department of Health, Division of Environmental Sanitation, the X-ray diffraction methods was used to determine the presence of taconite tailings "on the bottom or in the water extending from the tailings launder out into the lake as far as 5 miles and along the shore to the south and north up to 12 miles."

Mr. Robert Andrew, Research Chemist on my staff at the National Water Quality Laboratory, has used this same method to determine the tailings in samples collected at various locations. Mr. Andrew received his graduate training in soil science at Ohio State and Wisconsin University and minored in minerology. Mr. Andrew

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will discuss current methods used to identify cummingtonite in samples and the utility of that mineral to trace tailings.

MR. ANDREW: Thank you.

Mr. Chairman, conferees:

The mineralogical nature of the taconite tailings makes them ideally suited for study and analysis by X-ray diffraction methods. This method is the most widely used means of studying mineral, soil, and sediment materials, and is a highly sensitive one. It is used, for example, by the F.B.I. and other agencies for the identification and characterization of individual dust particles and paint flecks that may weigh less than one milligram. In the present work we have easily been able to identify the individual minerals in Lake Superior water in suspension at concentrations of less than 1 mg/l, (1ppm).

The X-ray diffraction method is generally semiquantitative, but by preparation of standard curves from mixtures of standard minerals, the method can be made quite quantitative with accuracy limited only to the gravimetric accuracy of preparation of the standard mixtures. A solid sample is mounted on a glass slide or similar sample holder, and a beam of X-rays is "projected" on a sample, the diffracted ("reflected") X-rays are measured in an arc around the sample using an electronic X-ray detector and recorder. In the case of water samples or sediment suspensions, the samples are filtered through a .45 micron membrane filter to collect the suspended solids, and the membrane is then mounted on the sample holder.

For identification purposes the angular location and intensity of the "reflected" peaks for an unknown material are compared

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with those of mineral and chemical standards in a card file published and maintained by the American Society for Testing Materials.

The method is highly specific and rarely is there any question as to identification of the mineral materials present, except in the case of complex mixtures. Even in these cases, the X-ray diffraction pattern may be used to "fingerprint" the material, even though the exact composition of the mixture is not known. Such mixtures are usually easily resolved by chemical treatments.

METHODS

For the present study, water, tailings, suspended sediments, and bottom sediment samples have been analyzed using X-ray diffraction techniques. Except in the very early phases of the study, sedimentation and/or centrifuge techniques have been used to separate and to define the particle size ranges of the suspended or solid materials prior to analysis. In each case the weights and percentage of the various size fractions have been determined.

The purpose of these size separations was twofold:

- (1) Separation of sample sediments into size fractions segregates certain mineral groups and greatly improves the resolution and accuracy of the X-ray diffraction analysis.
- (2) The analytical results for the various size fractions can be much more closely related to movement or transport of the particles in suspension in the waters of the lake.

The X-ray diffraction analysis were made for the most part on the less than two micron size particles, since these particles are most easily transported in suspension. A 2 micron particle, for example, settles at a rate of less than 1 foot per day in the cold waters of

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Lake Superior, and thus can be transported many miles by the lake currents before settling to the bottom.

Quantitative estimates of the percentages of the various minerals present in the samples were made by visual comparison of X-ray diffraction patterns and corresponding peak heights with cummingtonite and other mineral standards similarly prepared and analyzed. The percentage of taconite tailings present was estimated, using the peak height of the 8.3 angstrom peak of cummingtonite, and compared with the X-ray patterns of various size fractions of a composite tailings sample.

In some cases these estimates have been confirmed by additional heavy liquid and fusion separation methods. However, these techniques have been used on a limited number of samples, and additional work is in progress in this area.

Visual estimates based on peak height in this manner are accurate to approximately 5 percent of the mineral content in a given fraction. However, when a mineral such as cummingtonite is only found in a single size fraction, as in the Duluth water plant samples, which will be shown in a short while, the over-all accuracy in the whole sample is improved. For example, a mineral making up 30 percent plus or minus 5 percent of the clay fraction (less than 2 microns) of a sample having 10 percent clay, is 3 percent plus or minus 0.5 percent.

DISCUSSION

Mineralogically, the finer fractions of the taconite tailings are composed of quartz, cummingtonite, some noncrystalline

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iron oxides, and small quantities of the clay minerals chlorite, vermiculite, and montmorillonite. Of these minerals only cummingtonite can be used to definitively identify and trace the tailings at any appreciable distance from the discharge because quartz and the other minerals are quite common in the soils and sediments of the Lake Superior Basin.

Cummingtonite, which is a magnesium silicate mineral (classed as an amphibole) comprises approximately 1/3 of the fine fractions of the taconite tailings. Grunerite, and iron silicate with a similar structure and X-ray diffraction pattern is also present in very small amounts, but the proportion of the two varies from sample to sample and within various fractions of the same sample. Cummingtonite and grunerite are less common minerals of the amphibole group and their distribution in the Lake Superior Basin is limited exclusively to the taconites found in the Biwabik formations. They are not -- and I repeat they are not -- common in the ores or rocks of the western part of the Mesabi Range.

In the natural soils, sediments, and glacial deposits of the basin, the amphiboles, including cummingtonite, are found entirely in the coarser sand and silt fractions, where they comprise usually less than 10 percent of those fractions. Cummingtonite and the other amphiboles are not normally found in the finer fractions (less than 2 micron) of the natural soils and sediments of the basin.

In summary, we have used X-ray diffraction methods to show the unique mineralogical nature of the taconite tailings.

Similar studies of the natural stream sediments of the basin have shown that cummingtonite, a dominant mineral in the

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tailings, is absent in the fine fractions, which are those most easily carried in suspension in the waters of the lake.

Thank you.

DR. MOUNT: In order to further establish the validity of the use of cummingtonite and to follow the movement of tailings, I would like to read the following letter addressed to Mr. Dale Bryson from William C. Phinney, Professor of Geology:

INSTITUTE OF TECHNOLOGY • SCHOOL OF EARTH SCIENCES
DEPARTMENT OF GEOLOGY AND GEOPHYSICS • MINNEAPOLIS, MINNESOTA 55455

May 6, 1969

Mr. Dale S. Bryson
Federal Water Pollution Control Administration
East 58th Street and 40th Avenue South
Minneapolis, Minnesota 55450

Dear Mr. Bryson:

In answer to your query concerning the possible sources of cummingtonite which might drain into Lake Superior, I can give you the following information.

1. All of the streams from Duluth northeastward and draining into Lake Superior have their entire courses in rocks which do not contain cummingtonite. Most of the bedrock in the area consists of volcanic flows and gabbroic to intermediate igneous rocks none of which are known to contain cummingtonite. The only possible source of any cummingtonite in this area might be from material in the surficial glacial deposits but in all of the studies of this material the rock fragments are essentially all from rock types which do not contain cummingtonite. It would appear essentially impossible to me that this glacial drift could provide a measurable amount of cummingtonite in the streams draining through it.

2. The only known occurrence of cummingtonite in the drainage area within Minnesota leading to Lake Superior is at the eastern end of the Mesabi Range. There is only a small strip of metamorphosed iron-formation from about 3 or 4 miles N.E. of Mesaba to Birch Lake which contains cummingtonite. Most of this area from 3 miles south of Babbitt northeastward to Birch Lake drains through the Dunka River Watershed which drains northward to Birch Lake and Rainy River rather than Lake Superior. Only a small area which drains into the Partridge River could supply any cummingtonite to Lake Superior via the St. Louis River. However, the drainage is so sluggish, with several swamps and lakes occurring between the cummingtonite source area and the St. Louis River, that it seems unlikely for a significant amount of cummingtonite to reach the St. Louis River, let alone Lake Superior.

Sincerely yours,

William C. Phinney
William C. Phinney
Professor of Geology